July 1997

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PCS antennas, p. 10

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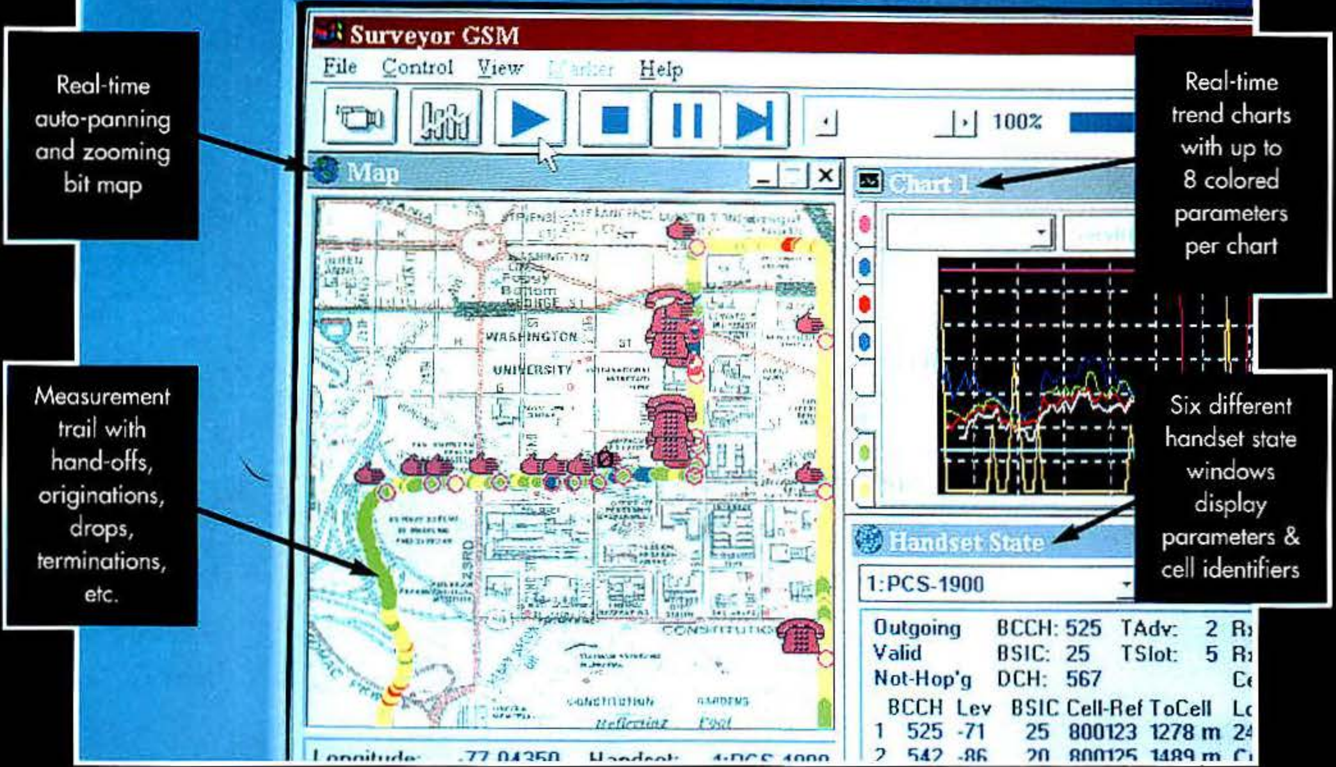

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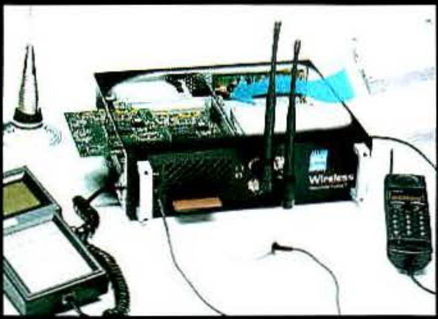

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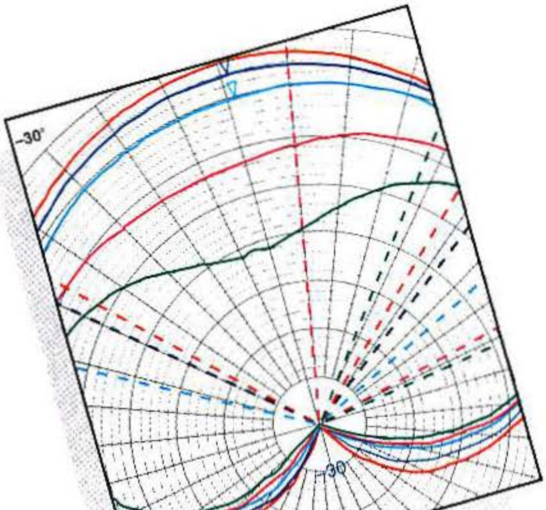

page 10


page 36

features

departments

On the cover: A world of options are available for DCS antenna beamwidths. But what is the right choice? Story begins on page 10. *Photo courtesy of Celwave.*

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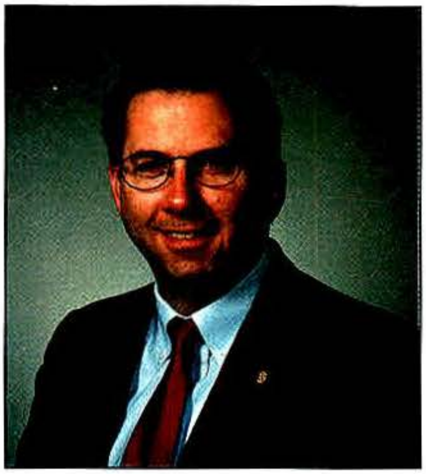
President Clinton's second term brings turnover at FCC



On May 27, FCC Chairman Reed Hundt announced that he had sent a letter of resignation to President Clinton. Hundt intends to leave the commission when his successor is confirmed by the Senate.

Hundt's letter said he wanted to spend more time with his wife and children. Accepting that reason at face value, and then looking beyond it, one could say that Hundt has achieved most of his objectives—or the White House's—and the remainder of his term through June 30, 1998, might have seen diminishing returns and increasing controversy.

For example, probably the lion's share of proceeds from wireless communications spectrum auctions already has been garnered. The decision was made not to auction high-definition TV channels, worth an estimated $70 billion. Many of the regulatory changes stemming from telecommunications reform legislation have been enacted.

The Clinton administration focused on using the FCC to collect billions of dollars to offset part of the federal budget deficit. As a result, the Hundt commission was mostly unresponsive to spectrum requirements for land mobile radio, including small SMR system operators and the business, industrial and public safety users of private radio.

Together with Hundt's departure, new appointees will fill four of the five commission seats.

Democrat James Quello's term expired June 30, 1996, and he remains in office until a successor has been confirmed. William Kennard, the FCC general counsel, was nominated on May 24 for the four years remaining in the five-year term.

Republican Rachelle Chong's term expired June 30, 1997, and she is likely to remain in office until a successor is confirmed. Michael Powell, chief of staff of the Justice Department antitrust division, may get the nod for a five-year term.

To fill out the remainder of Hundt's term, and perhaps a five-year term to follow that, White House economic adviser and former FCC Common Carrier Bureau chief Kathleen Wallman has been mentioned. So has Ralph Everett, a partner in the Washington law firm of Paul, Hastings, Janofsky & Walter and a former chief counsel and staff director for the Senate Commerce Committee under Sen. Ernest Hollings (D-SC).

Democrat Susan Ness will provide continuity as she continues in a term expiring June 30, 1999.

A Republican seat previously occupied by Andrew Barrett has been vacant since he left in 1996. Economist Harold Furchtgott-Roth was nominated on May 24 to fill the office for the three years remaining in that five-year term.

Contenders for the chairmanship include Kennard, Ness, Wallman and Everett.

The change in commissioners will bring in new advisers. (Each commissioner has three.) It would not be surprising to see a reshuffling among bureau chiefs and other staff, either. It will take some time before the agency regains the momentum it will lose during the transition.

It would be wonderful to predict improved regulation for SMR and private radio under a new chairman. If the White House directs the next chairman the same as it has Chairman Hundt, though, the effort required to advance the needs of SMR system operators and private radio users is one thing that won't change.

—Don Bishop

Additional comments about the resignation of Reed Hundt as FCC chairman:

Chairman Hundt accomplished many of his objectives at the helm of the FCC, and certainly facilitated the development of the wireless age for the American public. However, during his tenure, not much was necessarily accomplished for the private wireless industry. Perhaps if he had stayed longer, we would have had our day in the sun. With the pending leadership changes at the FCC, ITA anticipates that some critical proceedings may be delayed. Other than the recent gains made in the refarming proceeding, which by no means is out of the woods as yet, we still deserve attention and closure on a number of other proceedings. We also deserve a fair hearing in the pending reallocation of the 746MHz–806MHz bands.

—Mark Crosby, president, Industrial Telecommunications Association

The wireless industry has undergone more change during Chairman Hundt's tenure than at any other time in its history. Unfortunately, most of the change has been detrimental to small businesses in telecommunications. SBT hopes that the next chairman won't view spectrum solely on the basis of how much money it can raise, but will be more sensitive to, and considerate of, the needs of small business, private operators and the public interest in general.

—Lonnie Danchik, chairman, Small Business in Telecommunications

Under Chairman Hundt's leadership, the FCC has finally paid attention to public safety communications needs and has begun the critical process of finding spectrum to reallocate for public safety agencies. In particular, Chairman Hundt has led the charge to open up TV channels 60-69 for possible reallocation. We hope that the new chairman will follow Chairman Hundt's lead and finalize a reallocation of 24MHz of that spectrum for public safety.

—Ronnie Rand, executive director, Association of Public-Safety Communications Officials—International

Chairman Reed Hundt has done an exemplary job in overseeing the modernization of the Federal Communications Commission, streamlining its processes and meeting all of the FCC's Congressionally mandated deadlines.

—Jay Kitchen, president, Personal Communications Industry Association

Calendar

1997

August

10–14—International Association of Public-Safety Communications Officials (APCO) National Conference, Westin Hotel, Charlotte, NC. Contact: 904-322-2500.

September

10–12—Personal Communications Showcase, sponsored by the Personal Communications Industry Association, Dallas Convention Center, Dallas. Contact: 800-326-8638.

October

27–29—Wireless Apps, sponsored by the Cellular Telecommunications Industry Association, Seattle Convention Center, Seattle. Contact: Francesca Dea, 702-739-4025, or Tim Ayers, 202-736-3203.

November

6–7—AMTEX, sponsored by the American Mobile Telecommunications Association, Hilton at Walt Disney World Village, Orlando, FL. Contact: 202-331-7773.

6–8—Second International Congress on Commercial Trunked Radio, sponsored by the International Mobile Telecommunications Association, Hilton at Walt Disney World Village, Orlando, FL. Contact: 202-331-7773.

12–16—Communications Marketing Conference, sponsored by the Communications Marketing Association, Holiday Inn International Drive Resort, Orlando, FL. Contact: Bernie Brownson, 303-371-8182.

21—Radio Club of America, Communications Symposium, 88th Anniversary Dinner and Awards Presentation, New York Athletic Club, New York. Contact: Gerri Hopkins, 908-842-5070.

1998

February

23–25—Wireless, sponsored by the Cellular Telecommunications Industry Association, Georgia World Congress Center, Atlanta. Contact: 212-964-7000.

March

1–4—ENTELEC, sponsored by the Energy Telecommunications and Electrical Assocation, Marriott River Center, San Antonio, TX. Contact: 281-357-8700.

April

20–23—Expo Comm/Comdex, sponsored by E.J. Krause & Associates, McCormick Place, Chicago. Contact: 301-493-5500.

22–24—International Wireless Communications Expo, co-sponsored by *Mobile Radio Technology*, Las Vegas Convention Center, Las Vegas. Contact: 800-288-8606.

May

18–21—Supercomm, sponsored by USTA and TIA, Atlanta. Contact: 202-326-7300.

18–21—Vehicular Technology Conference, sponsored by IEEE Vehicular Technology Society, Westin Hotel, Ottawa, Canada. Contact: 908-562-3870.

June

20–22—Canadian Wireless, sponsored by the Canadian Wireless Telecommunications Association, Metro Toronto Convention Center, Toronto, Canada. Contact: 613-233-4888, ext. 102.

28–July 2—UTC National Conference & Exhibition, sponsored by UTC, The Telecommunications Association, Hynes Convention Center, Boston. Contact: 202-872-0030.

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Site noise vs. system noise figure

By Harold Kinley, C.E.T.

No matter how good the noise figure of *individual* components of a receiving system may be, it is the overall system *noise* figure that represents the bottom line in describing how well a receiving system will perform in the real world. To a large degree it is the ambient site noise in which the receiving antenna is placed that determines the overall system noise figure. In this column we will look at several receiving systems for a conventional narrowband FM (±5kHz deviation) system and compare the performance in high-, medium- and low-noise environments.

Antenna noise figure

Sometimes you will see the term *antenna noise temperature* used to describe the level of ambient site noise in which the antenna is placed. I prefer to use the term *antenna noise figure.* Figure 1 below shows a simple open-circuit resistor. Thermal noise voltage will appear across the resistor. The level of the noise voltage will depend on the resistance, temperature and bandwidth. The formula for noise voltage is(V_N):

$$V_N = \sqrt{4RkTB}$$

For 50W systems this can be reduced to

$$V_N = 14.14\sqrt{kTB}$$

where
k = Boltzmann's constant, or 1.38×10^{-23}
T = temperature in degrees Kelvin (K) and
B = bandwidth in hertz.

Generally, 290°Kelvin, or about 62°F, is considered to be earth's temperature. The noise voltage appearing across the 50Ω resistor shown in Figure 1 is 0.1096μV at 290°K in a 15kHz bandwidth.

The equivalent noise input of a receiver can be determined by the following formula: $N_R = 10\log(N_B) + N_F - 174$ where N_R = equivalent receiver input noise in dBm, N_B = noise bandwidth in hertz and N_F = receiver noise figure in decibels. If the receiver noise figure is 0dB and the noise bandwidth is 15,000Hz, then the equivalent noise input to the receiver is −132.24dBm or 0.0546μV rounded to 0.055μV.

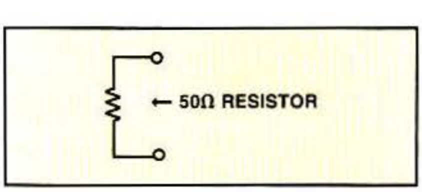

Figure 1. The open circuit thermal noise voltage across the 50Ω resistor is 0.1096mV

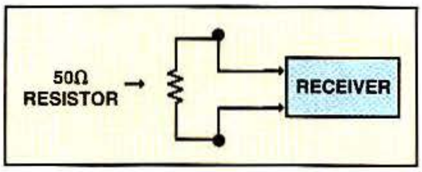

Figure 2. When the resistor is connected to the input of the receiver, the noise voltage from the resistor is reduced by one-half to 0.055μV, and the receiver with a noise figure of 0dB will have an equivalent noise input voltage of 0.055μV. This results in a total noise voltage of 0.0778μV at the receiver input.

Now, refer back to the 50Ω open-circuit resistor. It had a noise voltage of 0.1096μV across the terminals. If we connect this resistor to a 50Ω receiver with a 0dB noise figure (with the equivalent of 0.055μV noise voltage input), what happens? (See Figure 2 above.) Because the resistor is terminated in 50Ω (receiver input impedance), the noise voltage across the resistor will divide in half to produce 0.055μV of noise voltage across the receiver input. Now the resistor is contributing 0.055μV of noise, and the input noise at the receiver is 0.055μV. Because the two noise voltages are non-coherent, the total or resultant noise voltage at the input to the receiver is found from the *root-sum-square* (RSS) of the two voltages.

Thus, the resultant noise voltage at the input to the receiver is:

$$\begin{aligned} N &= \sqrt{N_R{}^2 + N_{Rx}{}^2} \\ &= \sqrt{0.055^2 + 0.055^2} \\ &= \sqrt{0.00605} \\ &= 0.0778\mu V \end{aligned}$$

Thus, with the 50Ω resistor connected to the receiver input, the noise voltage has increased from 0.055μV to 0.0778μV, representing an increase of 3dB. The noise figure has increased by 3dB with the connection of the resistor to the receiver, or simply, the resistor has a noise figure of 3dB. If we substitute an antenna for the resistor the antenna will have the same effect on noise figure; that is, assuming that the antenna is placed in an environment where site noise is negligible. It would be hard to find such a place in the real world. The main point is to show that an antenna will exhibit a noise figure of 3dB at a minimum. Normally, the equivalent antenna noise figure will be *much higher* than 3dB.

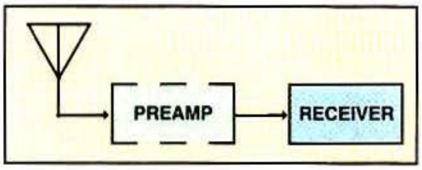

Figure 3. The basic receiving system is composed of the antenna, the preamplifier, transmission lines and the receiver.

System noise figure

Now, we will examine several examples of receiving systems to compare the effects of site noise with various amounts of line loss and with or without a tower-top preamplifier. Figure 3 above is our basic receiving system. The preamplifier (the dashed line) may or may not be in line for a particular series of data.

The receiver used in this table represents a sensitivity of approximately 0.25μV for a noise figure of 9dB. The first four lines of the table are for antennas with the best possible noise figure (3dB) representing a site with the lowest possible noise. Notice that the line loss affects the overall system noise figure almost on a decibel for decibel basis.

Lines 5–9 illustrate what happens when the antenna is at a site with moderate noise represented by a 10dB antenna noise figure. Notice that on line 5, for a 0dB line loss, the system noise figure is 12.3dB. On line 7, the line loss is increased to 4dB but only increases the system noise figure by slightly more than 2dB.

Lines 9–11 show some comparisons at a site where the site noise is high represented by a 20dB antenna noise figure. The overall system noise figure with a

(continued on page 50)

Kinley, a certified electronics technician, is regional communications manager, South Carolina Forestry Commission, Spartanburg, SC. He is a member of the Radio Club of America. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, which is available for direct purchase. Write to 204 Tanglewylde Drive, Spartanburg, SC 29301. Kinley's email address is *hkinley@aol.com*.

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Selecting antennas for PCS and DCS systems

Selecting antennas for a PCS or DCS system may be the most important decision an RF engineer makes. There are several points, including electrical issues, for the engineer to consider, and attention to detail is key.

By Andrew Singer

Many personal communications service (PCS) and digital cellular service (DCS) systems are being designed and optimized around the world. With system performance on the line, selecting antennas for a PCS or DCS system can be the most important decision an RF engineer makes. The antennas may represent only 1% to 3% of the total cost of a typical site, but they can have a big effect on performance. In fact, using a "dollar/performance" criterion, antennas can achieve the "most bang for the buck" of any system component. With this in mind, it is important to consider several points when selecting antennas for PCS and DCS systems.

Several electrical issues can significantly affect overall system performance. *Horizontal and vertical beamwidths* define antenna *gain*. Horizontal beamwidths typically used on PCS and DCS systems are 33°, 65°, 90° and 120°. Each has its proper application. Horizontal beamwidths at 120° are typically used by engineers who subscribe to the design theory developed during the early days of cellular. The conventional wisdom currently accepted is that 90° horizontal beamwidth antennas perform better in digital systems.

Singer is director of technical marketing at Celwave, Marlboro, NJ.

By using 90°, or even narrower antennas, excessive overlap is avoided as shown in Figure 1 below. This excessive overlap can cause higher bit-error rates (BERs) in digital systems and capacity loss because of excess soft hand-off zones in code-division, multiple-access (CDMA) systems. By using 90° or narrower horizontal beamwidth sector antennas, operators can also help reduce the possibility of capturing mobiles from adjacent sectors, thus optimizing hand-offs. For PCS and DCS systems, most operators use 90° horizontal beamwidth antennas in rural and suburban sites.

For core urban sites, some operators use 65° horizontal beamwidth antennas. The 33° beamwidth antennas can be used for special bidirectional "corridor" applications. By mounting two high-gain, 33° horizontal beamwidth antennas back-to-back and then feeding them through a two-way coaxial power divider, a high-gain, bidirectional pattern is created. This pattern is ideal for covering long interstate highway corridors.

When the antennas are combined with a power divider, however, the energy is defocused, thus decreasing the gain by 3dB. To maintain maximum gain, the antennas should be fed separately, with the RF channels split between the two. An example of a bidirectional array for corridor coverage is shown in Figure 2 below. The front-to-back ratio (F/B) is also an important aspect of the horizontal beamwidth. The F/B typically varies between 20dB and 45dB, depending on the model and manufacturer. Log periodic dipole array antennas usually have a

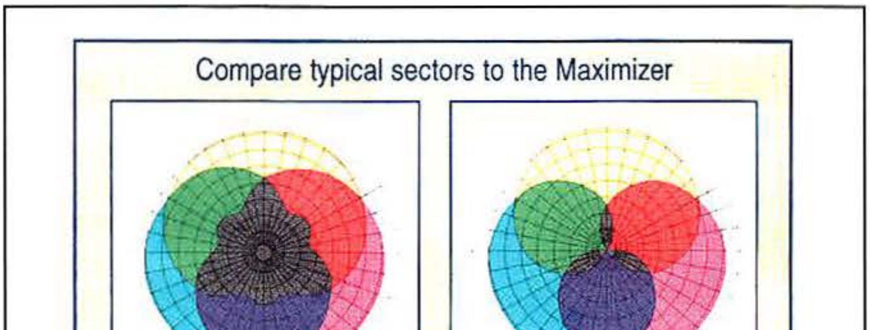


Figure 1. Excessive sector overlap created by antenna horizontal beamwidths of 120° (left) is reduced in digital systems by the use of beamwidths of 90° (right).

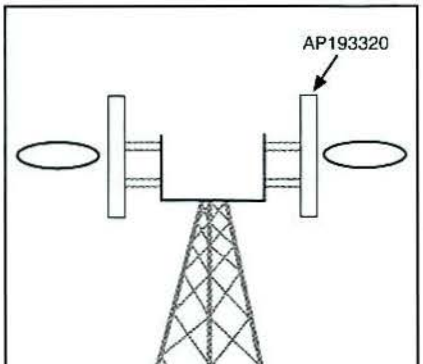


Figure 2. Corridor coverage applications where half the total channels are fed into each antenna.

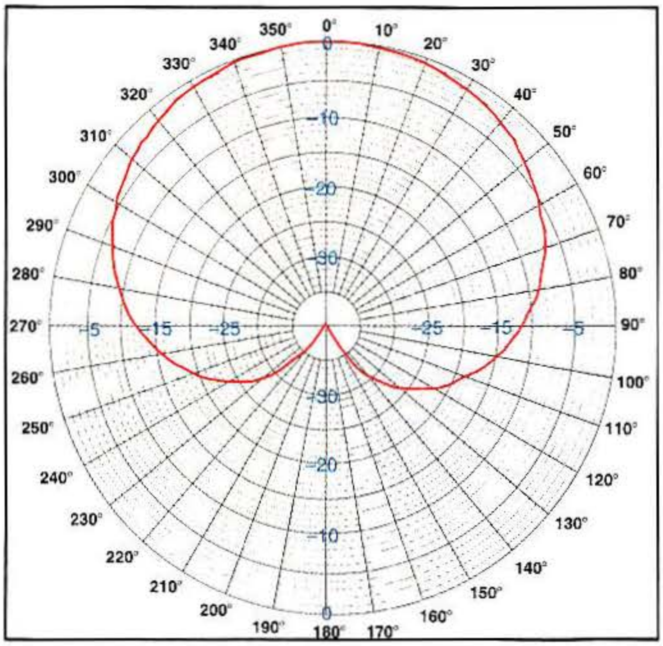


Figure 3. H-plane pattern at 1,990MHz.

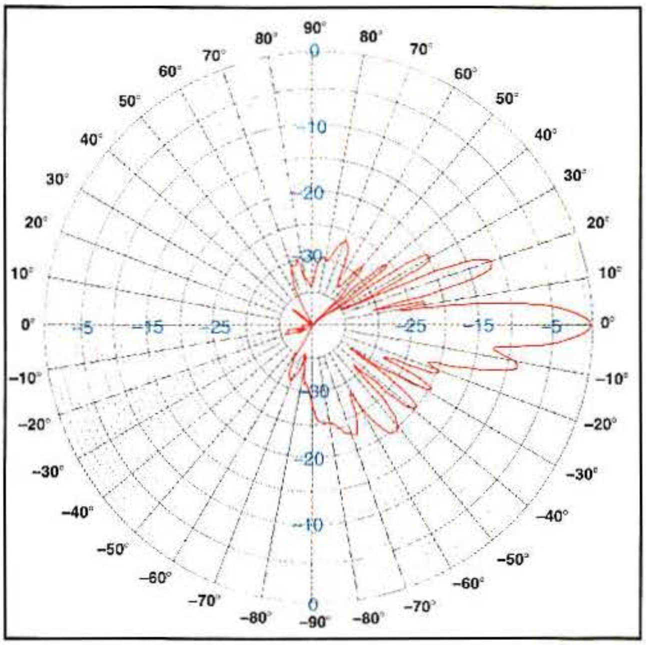


Figure 4. E-plane pattern with good null-fill at 1,990MHz.

higher F/B than panel antennas. The highest F/B available on the market today is 45dB, which is useful for rejecting co-channel and adjacent channel interference. Not only should you look at the front-to-back specification, but the overall reduction of signal toward the back of the antenna. The horizontal pattern of an antenna with a F/B of 45dB is shown in Figure 3 above.

Once a horizontal beamwidth is chosen, the next step is to determine the proper vertical beamwidth. Vertical beamwidth, horizontal beamwidth and antenna efficiency define the overall gain. PCS and DCS antennas are typically available in lengths from one foot to six feet. A six-foot-tall PCS-DCS antenna has a vertical beamwidth of about 4°. This is about as narrow a vertical beamwidth as should be used in a PCS or DCS system.

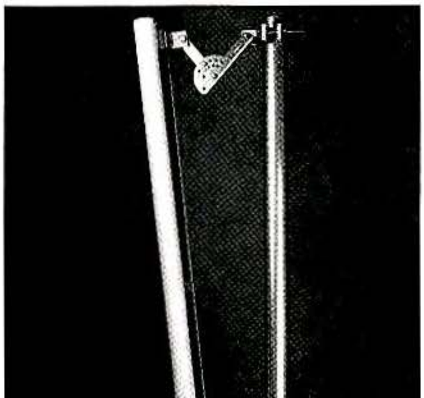


Photo 1. Cellite AP196516 with APM221-1, an antenna with 65° horizontal beamwidth, 7° vertical beamwidth and 16dBd gain.

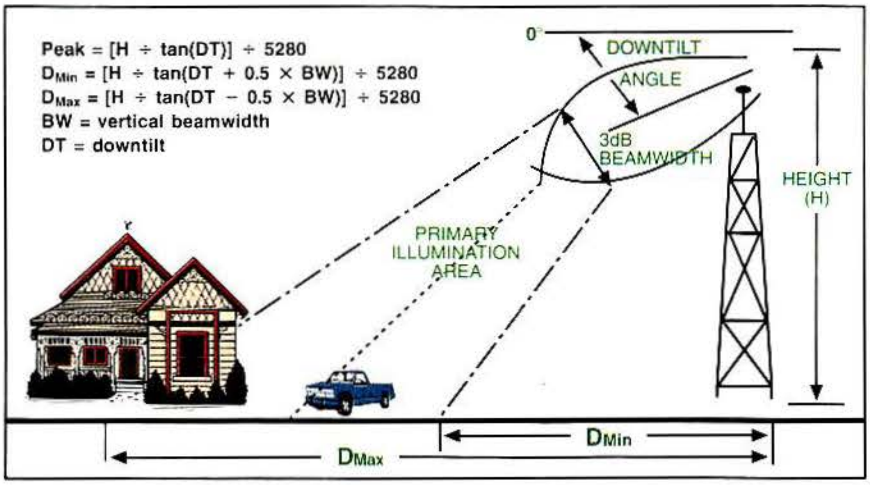
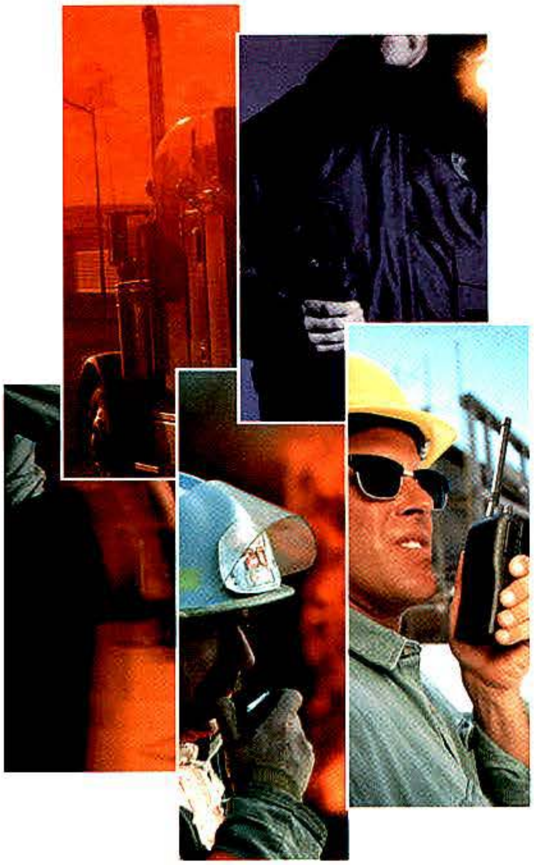
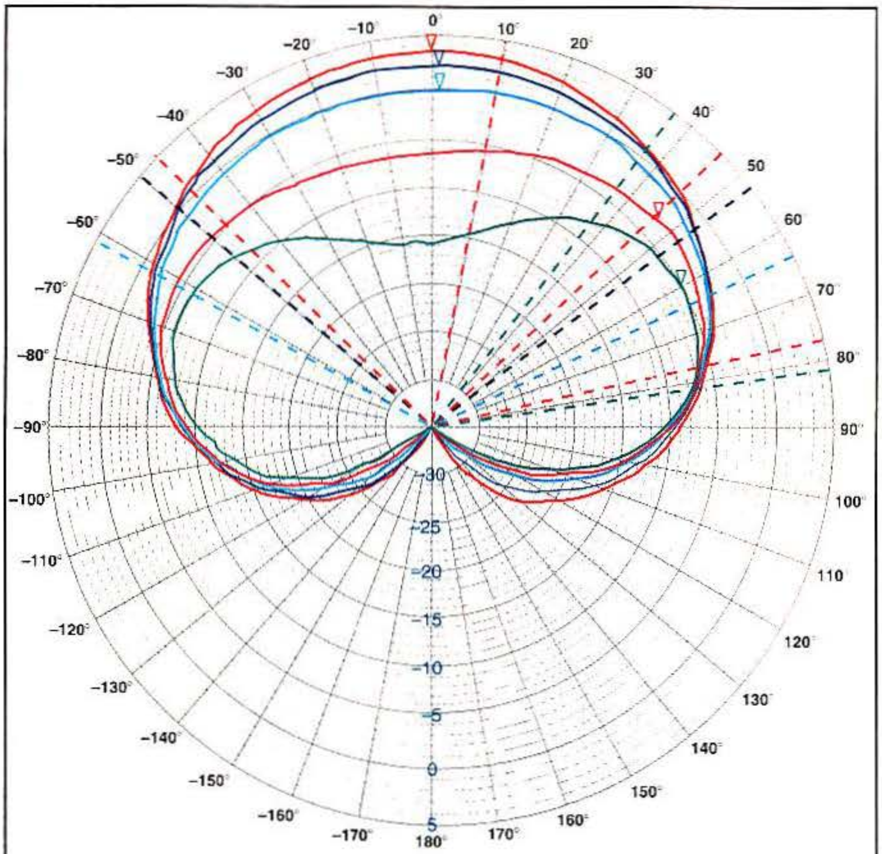


Figure 5. Use the equations to determine the proper degree of downtilt. Beware of simplified methods that only use two or three values for all sites. Downtilt should be determined on a per-site basis, particularly during 'coverage' stages for buildout.

A PCS antenna with a 65° horizontal beamwidth and a 7° vertical beamwidth should have a gain of about 16dBd. An antenna with these characteristics is shown in Photo 1 on page 12. Two PCS-DCS antennas with the same beamwidths should have about the same gain, provided they have reasonable antenna efficiency. Unfortunately, this is not always the case. Most operators use antennas between four feet and six feet in length for rural and suburban sites. For urban sites, antennas from one to four feet long are being used, depending on the particular application. The vertical pattern also defines the amount of null-fill available. Null-fill can be useful for improving coverage close to the site, particularly for low-power portables. An antenna with good null-fill can be seen in Figure 4 on page 12.

Downtilt is another issue that RF engineers often discuss when designing and optimizing PCS and DCS antenna systems. Downtilt focuses below the horizon. (See Figure 5 at the left.) First, because PCS and DCS systems reuse frequencies, controlling the level of signal on the horizon is important. By tilting the main beam below the horizon, less co-channel interference occurs at the site that reuses the same frequency. Second, focusing the signal below the horizon can help to improve close-in coverage. When designing a system, the operator must be careful to consider both issues when choosing the best amount of downtilt at each specific site. Some operators use a fixed value at every site, say 10°. This type of thinking can get the designer into trouble quickly. Every site has a specific height above average terrain (HAAT), desired coverage area and reduction of signal on the horizon. By using the equations in Figure 5, an RF engineer can more intelligently choose an initial value of downtilt for a particular site. Operators





Downtilt (°)	Beam peak (°)	Effective beamwidth (°)	Front-to-back ratio (dB)
2	0.08	92.29	−53.882
4	1.23	102.49	−51.498
6	1.39	124.78	−49.199
8	43.65	66.94	−39.987
10	59.96	44.45	−26.337

Figure 6. H-plane pattern on the horizon for an eight-element array at 1,920MHz, with varying degrees of mechanical downtilt.

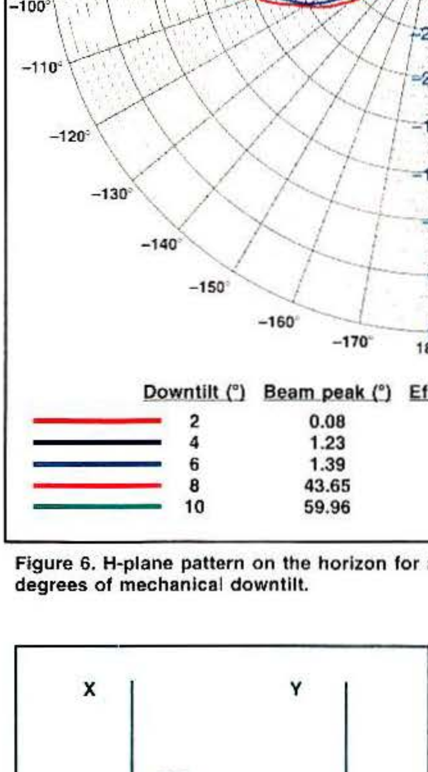


Figure 7. Although antenna 'Y' has a better VSWR than antenna 'X,' it uses lossy materials. The loss added to the system actually decreases performance.

should be cautious of companies offering solutions with a selection of signal reduction on the horizon, such as 3dB, 6dB and 12dB down. This type of solution does not consider the necessary coverage area, nor does it offer the optimized solution for each site. Once the optimal value of downtilt has been chosen, the RF engineer must decide among *mechanical* tilt, *electrical* tilt, or a combination. *Mechanical tilt* is achieved with a mechanical downtilt bracket designed for the antenna. *Electrical tilt* is designed into the antenna, and the operator purchases the antenna with a fixed value of tilt. Figure 6 above shows the H-plane pattern on the horizon for an eight-element array with a 90° horizontal beamwidth mechanically tilted 2°, 4°, 6°, 8° and 10°. As can be seen, with 10° of tilt, the horizontal beamwidth on the horizon is considerably distorted by mechanical tilt. However, the patterns with 4° of mechanical tilt show that with a reasonable amount of tilt, say 4° for an

Table 1—Compatible couples.

GROUP NO.	METALLURGICAL CATEGORY	EMF (VOLT)	ANODIC INDEX (01 VOLT)	COMPATIBLE COUPLES
1	Gold, solid and plated; gold-platinum alloys; wrought platinum	+0.15	0	
2	Rhodium plated on silver-plated copper	+0.05	10	
3	Silver, solid or plated; high silver alloys	0	15	
4	Nickel, solid or plated; Monel metal; high nickel-copper alloys	−0.15	30	
5	Copper, solid or plated; low brasses or bronzes; silver solder; German silver; high copper-nickel alloys; nickel-chromium alloys; austenitic stainless steels	−0.20	35	
6	Commercial yellow brasses and bronzes	−0.25	40	
7	High brasses and bronzes; naval brass; muntz metal	−0.30	45	
8	18% chromium-type corrosion-resistant steels	−0.35	50	
9	Chrominum, plated; tin, plated; 12% chromium-type corrosion-resistant steels	−0.45	60	
10	Tin plate; terne-plate; tin-lead solders	−0.50	65	
11	Lead, solid or plated; high-lead alloys	−0.55	70	
12	Aluminum, wrought alloys of the duralumin type	−0.60	75	
13	Iron, wrought, gray, or malleable; plain carbon and low alloy steels armco iron	−0.70	85	
14	Aluminum, wrought alloys other than duralumin type; aluminum, cast alloys of the silicon type	−0.75	90	
15	Aluminum, cast alloys other than silicon type; cadmium, plated and chromated	−0.80	95	
16	Hot-dip-zinc plate; galvanzied steel	−1.05	120	
17	Zinc, wrought; zinc-base die-coating alloys; zinc, plated	−1.10	125	
18	Magnesium and magnesium-base alloys, cast or wrought	−1.60	175	

NOTE: O = the most cathodic member of the series. ● = An anodic member, and the arrows = the anodic direction.

eight-element array, there is no significant difference between mechanical and electrical tilt. The H-plane cut at the angle of mechanical tilt has the same pattern as the antenna without mechanical tilt. It is for this reason that mechanical tilt makes so much sense for reasonable values of downtilt. As long as no more than 10° of mechanical tilt on a four-element array, 4° to 5° on a eight-element array and 2° to 3° on a 12-element array are used, there is no significant distortion of the horizontal pattern, and the mechanical tilt allows for optimization of tilt in the field. If electrical tilt is required because of the amount of tilt needed, it may be wise to use a combination of electrical and mechanical tilt. The mechanical tilt bracket allows for easy adjustment of the tilt during the site optimization stage.

Last, but not least, among electrical issues to consider when choosing PCS and DCS antennas is *voltage standing wave ratio* (VSWR or return loss). Many operators choose antennas based on VSWR, but one must be careful when assuming that low VSWR means high quality. Back in the CB radio days, there was a company "X" that manufactured a high-quality $^5/_8$-wave mobile antenna. This antenna had a VSWR of about 1.5:1. A new manufacturer, company "Y," developed a $^5/_8$-wave mobile antenna with a VSWR of 1.2:1. However, the low VSWR was achieved with a lossy coil. The antenna's overall gain was lower than the antenna from company "X," as can be seen in Figure 7 on page 16. Unfortunately, company "Y" took over the market with the antenna with less gain only because it had a better *VSWR*. Another way to view this situation is to imagine that every site in the system has an antenna VSWR of 1.5:1. The director of engineering comes to you on Friday afternoon and says, "Every site better have a 1.3:1 VSWR by Monday morning, or else." One easy way out is to go to an electronics store and buy a couple hundred 3dB loss pads. Install one on the output of every antenna over the weekend and, *voilá*, every antenna has a VSWR of about 1.22:1, and you never need to find out what "or else" means. Of course, there is one problem. Every antenna has its gain reduced by 3dB. The moral of the story is that lossy materials in an antenna will give the antenna a better VSWR, but they will also reduce gain and system performance.

When PC board antennas are used at 1.9GHz, a similar situation arises. If you measure a PC board antenna for VSWR, it looks great, but try to measure one on an antenna range for gain, and you will typically find that they do not have the gain you would expect for the vertical aperture of the array. When selecting antennas, it is wise to have the antennas measured on an antenna range for gain and patterns. This should preferably be done all on the same day and with one of your engineers as a witness. (It is amazing how a laptop can improve digitized patterns.) Many of the PCS-DCS antennas on the market do not meet advertised gain specifications. Although a half dB is not worth quibbling over, some of these products are overrated by 2dB, or even 3dB. The only way to protect yourself is to verify advertised antenna gains on an antenna test range.

Along with these electrical issues, it is just as important to consider mechanical issues. Catastrophic antenna system failures usually can be traced to poor mechanical antenna design. By looking for a few key features, you can help to protect yourself from these catastrophic failures. A key ingredient in successfully designing PCS and DCS antennas is to use the proper materials. Table 1 on page 18 shows compatible couples. Using this table, engineers can determine which metals can be placed in contact with other metals without causing galvanic corrosion. Galvanic corrosion can lead to intermod (IM) over time.

Another issue with the mechanical design of antennas is the large number of cables and solder joints used in certain designs. These soldered joints can be difficult to control and may break down over time, or may leave the factory in less-than-perfect condition. Although an antenna with numerous soldered joints may have no intermod when it is tested at the factory, operators have to be concerned with how it performs over the long term. One way to avoid this problem is to avoid cables and soldered joints completely. Although this is not always possible, sometimes a third construction technique can be used. By using a "monolithic" construction, the reliability of an antenna can be greatly increased. Photo 2 on page 22 shows an antenna constructed with this type of new technology. By eliminating cables and soldered joints, this monolithic technology improves the probability that an antenna will function reliably over the long term. If an antenna's chance of failure is statistically related to the number of soldered joints, eliminating all of the joints should dramatically reduce the number of catastrophic failures in the field. The monolithic design also has an added benefit that the feed lines use air as a dielectric, which helps to reduce loss.

Another key mechanical aspect of an antenna is the *connector*. Most PCS and DCS operators are using 7/16 DIN connectors. They use these connectors on antennas for their good intermodulation specifications and durability during installation. Another aspect for RF engineers to consider when selecting antennas for PCS and DCS systems is environmental testing such as IEC (International Electro Technical) testing. Table 2 on page 22 shows the minimal IEC testing a manufacturer should perform on an antenna design. When discussing IEC testing with your antenna vendor, be sure to ask for a copy of the results. You should receive a description of each test along with final VSWR, patterns and IM test

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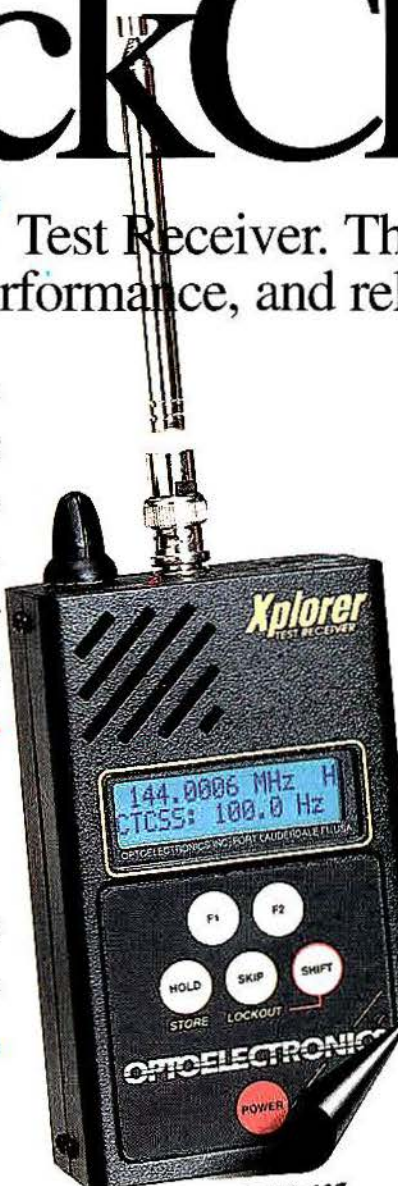

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SPECIFICATIONS	
Freq. Range	30MHz - 2GHz
Modulation	FM Deviation
Freq. Response	50 - 3000Hz
Auto Sweep Time	<1 second
Input 50 Ohm	-59dBm @100MHz -25dBm @1GHz
Display	2 line LCD
Power	Internal NiCad

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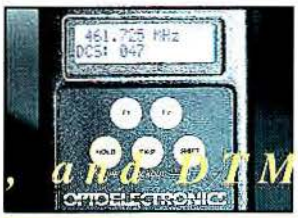

DCS Decode

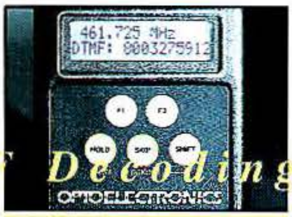

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Photo 2. PCS antennas that have been assembled using 'monolithic' construction techniques.

results after all the tests have been completed.

A new development in antennas is *polarization diversity* antennas. Cellular and PCS systems use a concept known as *space diversity* reception to improve uplink performance and to help balance the uplink and downlink paths. Space diversity works under the assumption that an antenna spaced 10λ horizontally from another antenna will not manifest signal fading identical with that of the first antenna. With a diversity receiver combiner that can use both antennas, the average uplink signal is improved between 4dB and 8dB, depending on conditions (and whose textbook you read). Polarization diversity is based on the assumption that the signal arriving from a portable phone in a multipath environment will exhibit random and changing polarization at the base site. By using an antenna that has elements in +45° and −45° polarizations, the signals can be fed into a diversity combiner, and the average signal can be improved. This polarization diversity technique has been shown to be basically equivalent to space diversity schemes in urban and heavy urban environments with a lot of multipath. An operator considering polarization diversity needs to keep two important points in mind: First, polarization diversity only works for portables in high-multipath environments. This technique may not work well in suburban and rural areas with little multipath. Second, polarization diversity generally uses two input antennas, which requires duplexing the transmitters with one of the receiver outputs. Many of the PCS-DCS polarization diversity antennas exhibit poor IM performance. When checking IM on some of these antennas, I have seen some third-order products reach −60dBm to −80dBm with two 20W inputs. I have even seen this level on some standard, vertically polarized PCS antennas. Even the fifth-order levels on these antennas would cause serious noise problems and call quality degradation once a system is loaded. Any operator considering polarization diversity antennas, or any antenna to be used in a duplexed system, should ensure that the antennas exhibit excellent IM performance. One method of testing the IM performance of a particular design is to obtain several samples and test them at an IM test facility. Because most PCS-DCS carriers will only see fifth-order hits, a third-order level of −100dBm with two 20W inputs should be the minimum acceptable level.

Table 2—Minimum IEC68-2 Tests

IEC68-2-1 Cold: 16 hours at −40°C
IEC 68-2-2 Dry Heat: 16 hours at +70°C
IEC68-2-11 Salt Mist: 48 hours in salt tank @ 5% salt solution
IEC68-2-14 Change of Temp.: +70°C to −40°C two cycles, 2hr. dwell
IEC68-2-18 Rain: 10mm/hr. at various angles
IEC68-2-26 Vibration: Varied frequencies and multiple axes
IEC-68-2-30 Humidity: 24 hrs. @ 55°C and 95% humidity, six cycles

An RF engineer can often ascertain a lot about an antenna design by looking at the little details. Do the downtilt clamps that came with your antenna look as though your child made them from an erector set? How will they hold up in a 100mph wind? What about a 125mph wind? Does the antenna have a drain hole? Has the antenna been opened to examine internal construction and workmanship? Have you performed the "jump" test on the antenna? Additionally, keep in mind that it can pay to spend a few more dollars and make sure you are purchasing high quality, reliable antennas for your PCS or DCS system.

The author would like to hear how your PCS-DCS antennas have been performing and about any experiments being conducted.

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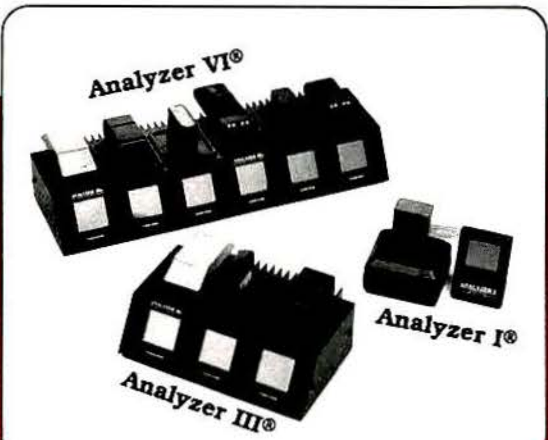

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Testing the performance of digital technologies

Different digital standards result in different test methods and specifications. Field test equipment that generates and receives digital signals can improve maintenance of emerging radio systems.

By Doug Mach, M.S.E.E.

The new digital systems are changing the way radio performance is specified and measured. Ensuring the best system operation and user satisfaction requires that new tests and measurements be made to properly maintain the equipment. Here are some of the similarities and differences in performance measurement between existing FM radios and some of the new digital systems.

Digital radio standards differences

Anyone who has serviced two-way radios is familiar with the tests and measurements used to confirm proper operation of analog FM radios. The most basic measurements commonly made in the field are likely to be power output and receiver sensitivity. Simple talk-and-listen tests verify that the radio is ready to be put back into service.

Mach is engineering manager for two-way products at Motorola Communication Test Equipment, Scottsdale, AZ.

The new digital standards have changed things quite a bit. Different digital standards result in different test methods and specifications, which further complicates the issue. The method of specifying and measuring the two basic parameters of power output and receiver sensitivity varies from system to system.

A digital radio or system is one in which the desired intelligence (either voice or data) is transported by digital, rather than analog, means. Systems using digital signaling—such as trunking control channels or those transmitting low-speed digital data—have been around for years. Voice systems using a 12kbps data rate have been in operation on the land mobile bands since at least 1976. In this case, some audio quality is sacrificed for security and simplicity.

Two trends have resulted in the development of new radio technology:

- The increasing ability to pack higher and higher data rates into existing radio channels using improved modulation techniques.
- New voice compression technology allowing increasingly lower data rates without sacrificing good audio quality.

Low-power-consumption microprocessors make it possible to use both of these computation-intensive trends.

Understanding the basic layers of a digital system helps in understanding the issues raised in measuring performance. The most basic layer is the over-the-air connection. This layer establishes a stream of data between two radios: The type of RF modulation is specified, and the means for establishing synchronization and data framing is determined. (See Figure 1 below.) At this point, the

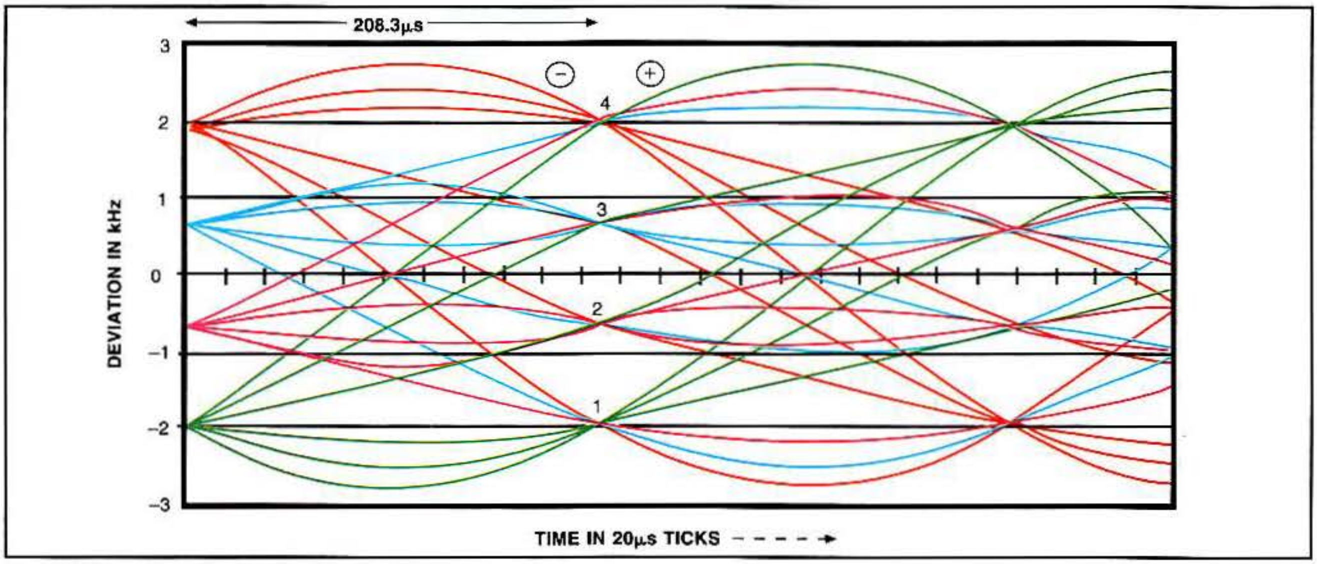

Figure 1. Eye pattern for four-level modulation.

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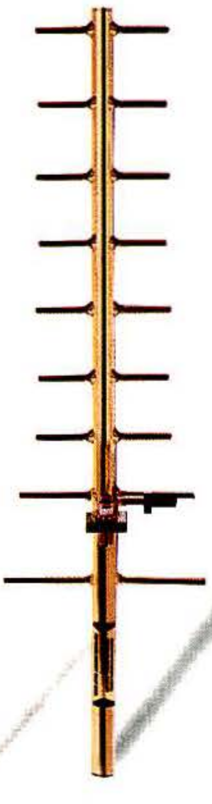

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traditional radio begins to evolve into a digital device. Once the radio-to-radio data connection is established, data are then passed on to be processed for signaling information, user verification, error correction and other radio control functions. Channels of data, including voice data, are prepared to be passed on to their appropriate applications. In the case of voice operation, data pass on to the vocoder.

For voice transmissions, the vocoder converts analog voice information into a stream of digital data that can then be transmitted on the established data channels. On the receiving end, the reverse process is carried out. Many types of vocoders are available today, each with good and bad attributes. For two-way land mobile communications, some of the desirable characteristics are:

- Good audio quality under noisy conditions.
- Good data compression.
- Immunity to degradation of voice quality caused by received bit errors.

On a voice channel, the resulting intelligibility is of key importance.

As in analog systems, power output and receiver sensitivity are important measurements of digital radio performance. How power output is measured depends on the type of digital system being measured. For an FM system such as an APCO Project 25-compliant system using C4FM modulation, the measurement is identical to that for an analog FM system. In the case of TDMA systems such as iDEN*, where the transmitter is pulsed on and off, a more complicated method that takes into account the duty cycle must be used.

Measuring receiver sensitivity is more difficult. A common method of measuring sensitivity in a digital data system is the bit-error rate (BER). This measurement compares a known transmitted pattern with the received data stream and expresses the result as a percentage of the bits in error.

The problem with using BER to indicate receiver sensitivity is that its effect on radio voice performance depends, to a great extent, on where in the radio layers the measurement was taken. For instance, a single bit error that results in the loss of synchronization could result in a series of incorrect bits being sent to the vocoder. How well the vocoder reacts to this series of incorrect bits determines the effect of this single bit error on intelligibility. On the other hand, various levels of error correction may be used before data are sent to the vocoder. This would correct for a single over-the-air bit error and, therefore, would have absolutely no effect on voice quality. Measuring only the over-the-air BER before framing, error correction and vocoding may not always be the best indication of actual voice performance.

Standards have been developed for C4FM digital radios compliant with APCO Project 25. In this case the desired test signal is a four-level, digitally modulated signal that produces a 1,011Hz tone when fed into the proper vocoder. Because this bit pattern is known, observing it at the receiver and comparing it to the expected result yields a BER measurement. The reference level has been set at a 5% BER. Sensitivity of these digital radios is expressed as the test signal level that results in a 5% BER.

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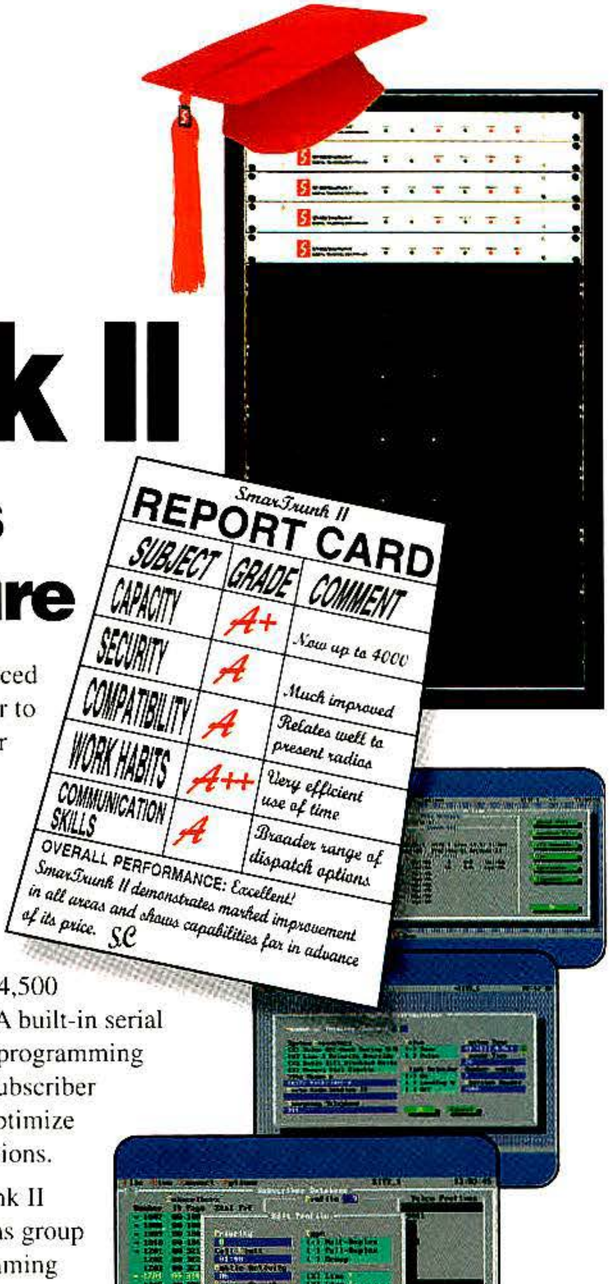

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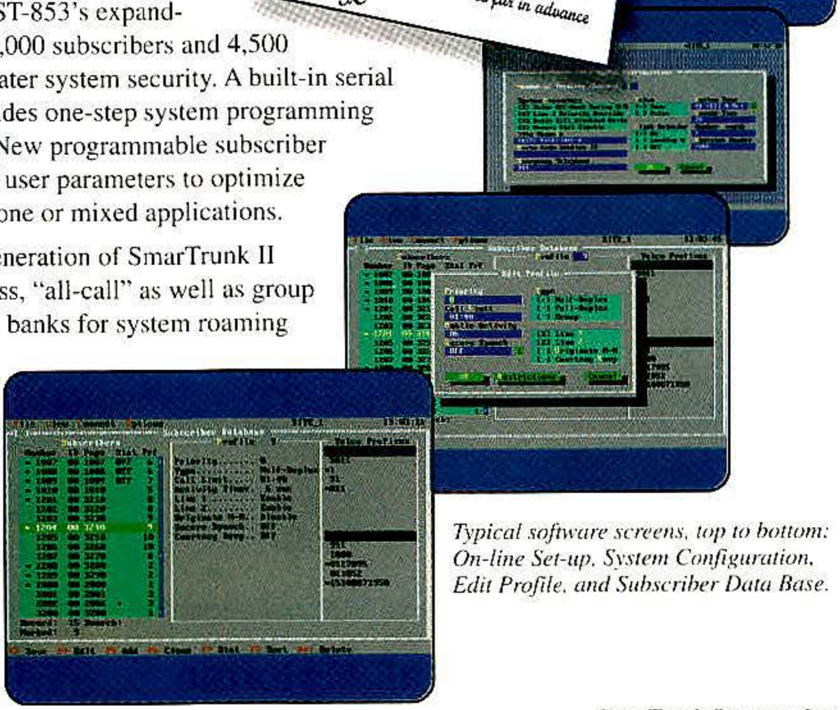

Typical software screens, top to bottom: On-line Set-up, System Configuration, Edit Profile, and Subscriber Data Base.

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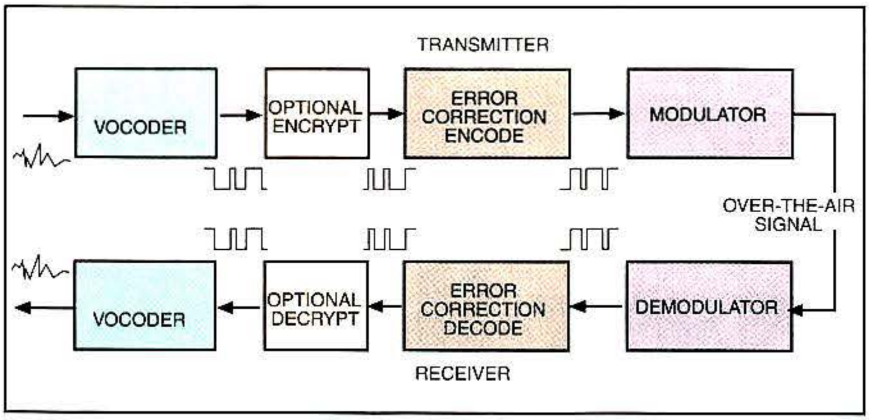


Figure 2. Voice signal path through a typical digital radio. Analog voice is digitized in the vocoder before being passed through a number of digital processes. The modulator converts the signal to an analog over-the-air signal. The reverse occurs in the receiver. The point where BER is measured affects what BER level is acceptable.

A test signal for a silent tone has also been established for these same radios. This signal allows hum and noise measurements to be made in a manner similar to analog radios. The silent tone delivers a series of bits, which when delivered to the specified vocoder, produces silence. The test tone signal is used by the radio to produce an audio reference level. The signal is then replaced with the silence tone, enabling hum and noise measurements to be made.

Interference testing of APCO Project 25-compliant radios follows the same pattern. In this case, the standard test tone signal is used to set the reference sensitivity level. The desired signal level is then increased by 3dB. An interfering signal on the adjacent channel is then added. This signal is a C4FM-modulated signal that has a bit pattern consisting of a specified, repeating pseudo-random sequence. The level of this signal is then increased until the reference BER increases back to 5%. This process is similar in nature to the familiar analog FM measurement.

Also, as with analog FM, several additional laboratory tests ensure acceptable radio performance within the digital system. Tests such as attack time, adjacent channel splatter and timing accuracy tend to be complex. These tests are generally more suited for the laboratory or, possibly, a production setting.

New test equipment requirements

The new digital radio systems pose new requirements both for laboratory and field testing. Test equipment that supports maintenance of radios used in the new emerging systems must contain modulators and demodulators capable of generating and receiving the specialized physical signals each system requires. Each system has unique, exclusive framing and error correction methods. In addition, each system has its own type of vocoder and they are generally incompatible. To make testing matters worse, these digital systems lend themselves well to encryption.

Because the voice message is already converted to digital form, it is a natural extension to add digital encryption; however, it produces yet another compatibility challenge for test equipment and radios.

To keep field equipment portable and reasonably priced, a distinction must be made between field and laboratory measurements. The interference measurements described for both analog and digital systems are typically laboratory measurements because of their complexity and the requirement for specialized equipment. The more basic types of power and sensitivity measurements are useful in the field. Because many of the digital radios also operate in the analog mode, the field test equipment must also be capable of performing the traditional analog FM measurements.

A communications analyzer used in the field to maintain digital radio equipment should be able to accurately measure power output. For APCO Project 25-compliant radios using C4FM modulation, a standard wattmeter used to measure power in analog FM systems should be adequate. For other digital systems, more complex power meters may be necessary. In TDMA systems, the wattmeter must be capable of handling the pulsed nature of the transmitter.

Measuring receiver sensitivity requires the generation of a specialized test signal. This signal must have physical characteristics matching the system being tested. Additionally, depending on the system and test method being used, the correct framing, error correction and voice or data bits must be included. The ability to generate other test signals, such as the silence pattern and the interfering signal pattern specified in the C4FM digital radio standard, may also be useful.

One traditional test, commonly used for maintaining most analog radios, is a talk-and-listen test. The ability to pick up a microphone and hear your voice come out of the radio under test goes a long way in gaining confidence that the radio is working properly. Because the digital radios use a vocoder, special capability must be added to allow this test. The test equipment could be made to store voice data transmitted to it by a working transmitter and then retransmit this data to the receiver under test. If the test is unsuccessful, some uncertainty is left as to whether the receiver or transmitter was at fault. A more complete way of performing the test would be to include a complete vocoder within the test equipment itself.

Looking ahead

The new digital radios definitely create a new challenge to field testing and maintenance. Along with the usual analog measurements, new methods must be used to perform basic tests in the digital mode. In the case of APCO Project 25-compliant radios, the test methods are well-developed in the C4FM performance recommendation and measurement methods documents.

Many of these tests are familiar to those who have tested analog. Field test equipment capable of generating and receiving these specialized signals can help to make maintenance of these new radios more productive and efficient.

References

EIA/TIA TSB102.CAAA Digital C4FM/CQPSK Transceiver Measurement Methods

EIA/TIA TSB102.CAAB Digital C4FM/CQPSK Transceiver Performance Recommendations

Switching vs. linear power supplies

Have you heard the latest about switching power supplies? The newest designs offer persuasive advantages compared with linear power supply technology.

By Paul Watkin

Power supplies serve extensive wireless communications applications. Basic distinctions between linear and switching power supplies make a difference, depending on the specific application. Each type has its own advantages and disadvantages.

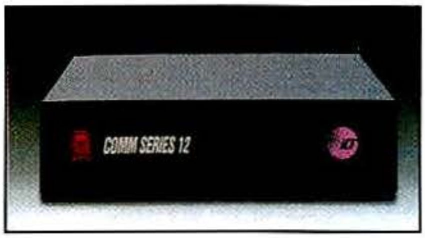
Transformers

Power supplies contain two main circuits: a primary side and a secondary side. The primary side connects to the power source, and the secondary side connects to the load. The interface between the two main circuits is the heart of the supply: the transformer.

Transformers convert the voltage available on the primary side to the required voltage level on the secondary side. Energy transfers from the primary side to the secondary by the continuous building up and collapsing of a magnetic field. Alternating current passing through the primary winding generates this field. The transfer of energy, from the primary to the secondary, takes place during the build-up and collapse phase of the magnetic field. This electromagnetic energy gets picked up by the secondary winding to generate the required voltage on the secondary side.

The voltage generated on the secondary side is generally proportional to the ratio of number of wire turns between the primary and the secondary windings. A transformer is normally made of a *primary winding* of copper wire, which is isolated from a *secondary winding*, and a *core*, which is made from a ferrous material such as iron or ferrite. Design and construction of a transformer requires consideration of such things as input and output current, voltage, core cross-sectional area and materials, insulation materials and methods, physical size and style, and temperature rise caused by core and wire losses. A transformer that has not been designed correctly may have less efficiency and may be electrically unsafe.

Watkin manages product development for ICT, Surrey, British Columbia, Canada.



Contemporary switching power supplies offer advantages in light weight and size, coupled with improvements in noise control, and reliability. *Photo courtesy of ICT.*

The basic technology behind switching transformers is: As the rate of change of the magnetic field increases in the transformer (i.e., increase in switch frequency), the transformer can be made smaller with smaller cores and wires to produce the same output power. Lighter core materials such as ferrite can be used instead of laminated iron. The resulting transformer assembly becomes much smaller and lighter than its linear counterpart.

Linear supplies: basic theory

The incoming ac voltage is stepped down to a lower ac voltage. For example, 120Vac is stepped down to 24Vac. The 24Vac is then rectified through a full-wave bridge rectifier, usually with a high-current, low-voltage bridge. A filter capacitor is used to maintain a constant dc level with minimum ripple.

The output voltage is controlled by a power transistor operating in its linear region. It acts as a variable resistor in series with the load. The power transistor receives its control from a circuit that senses output voltage. The control circuit modifies the transistor bias to maintain a constant voltage output, regardless of changes in the load current.

Switching supplies: basic theory

The incoming ac voltage is rectified and filtered to produce a high-voltage dc. A low-current, high-voltage bridge rectifier (that may not require a heat sink) can be used, as opposed to the linear bridge.

A power transistor—a metal-oxide semiconductor field-effect transistor (MOSFET)—is connected in series with the transformer. The MOSFET serves as an on-off switch and switches at a preset frequency. While the MOSFET is switching, the magnetic field in the transformer is building and collapsing, allowing energy to transfer to the secondary side.

The magnetic energy received by the secondary windings of the transformer is then full-wave-rectified and reconstructed into the proper dc level. A sample of parameters (V_{out}, I_{load}, etc.) can be sent back to the primary side to serve as input to the pulse-width modulator (PWM). The PWM circuit modifies the length of time that the MOSFET is switched "on" in order to maintain output regulation. For example, in a switching power supply producing 12Vdc and powering a 3A load, an increase in the load to 4A causes the output voltage to drop slightly. The feedback circuit detects the voltage drop and passes it to the PWM, which turns the MOSFET on for a longer period (i.e., it increases the duty cycle), causing more magnetic energy to transfer to the secondary side until the output voltage reaches its predetermined value.

Switching frequency

Frequency for a switching power supply usually ranges between 30kHz and 150kHz, but it can be much higher. Frequency for linear power supplies is the same as the line frequency (60Hz in North America). Switching frequency selection

depends on the application for which the power supply is designed. Because high frequency switching occurs at f_o, harmonics are generated at $3f_o$, $5f_o$, $7f_o$.... The selection of the frequency has to be such that none of these harmonics will interfere with the load. With power supplies for two-way radios, for example, the switching frequency should be selected so as not to interfere with VHF, UHF or the intermediate frequencies (IF) used in the radios.

Advantages and disadvantages

▶ *Linear* — One advantage of linear power supplies may be familiarty, because they have been available for many years. They are known to be relatively noise-free and reasonably reliable. They are generally easy to design and fairly inexpensive to manufacture.

Because of the large transformers required, linear power supplies are generally heavy, which may be either an advantage or a disadvantage, depending on the need to balance weight distribution in a given application. As a general rule of thumb, a 16V-output linear power supply weighs about one pound per ampere. A possible disadvantage of linear power supplies relates to the power transistor used to regulate the load. Because the power transistor operates in its linear region, and all the output current must pass through it, it requires large heat sinks to dissipate energy loss. (Recall that the power transistor is in series with the load and acts as a variable resistor.) Except in rare instances where heat is wanted to warm interior space, the inefficiency of linear power supplies—50%—has to be considered a disadvantage.

▶ *Switching power supplies* — Although switching power supplies have been available for a number of years, higher production costs, compared to linear power supplies, have limited their use in some applications. Early switching power supplies used discrete components to control pulse width, and transistors instead of MOSFETs as main switch components. As a result, the disadvantages of switching power supplies once included uneven reliability and radiated EMI (electrical noise). Although they were known to be noisy, unreliable and difficult to mass produce, switching power supplies had the advantage of being lighter and smaller than their linear counterparts. In the last few years, big improvements in PWM and MOSFET design have been made. Today, when all design considerations have been taken into account, switching power supplies are highly reliable and virtually noise-free. Production costs have come down because application-specific components are being designed for use in switching power supplies.

Switching power supplies are about 80%–90% efficient. Higher efficiency usually is an advantage, because heat normally is considered to be wasted energy (at the least) and potentially damaging to nearby electronic components.

Conclusion

Switching power supplies are gaining in popularity mostly because of their smaller size and lighter weight. Reliability and noise characteristics are becoming less-and-less of an issue as customers learn about the latest product developments. When assessing efficiency, size and cost of shipping, one has to consider the alternative to a linear power supply: the switching power supply.

Battery technology for portable applications

Battery design considerations such as capacity, chemistry selection, weight and energy density are driven by the requirements of equipment manufacturers whose devices will be powered by the portable power supply.

by Danny Amato and Al Crisafulli

As technology advances, the power requirements of portable electronic devices also change. Because of improvements in battery technology, battery cells have consistently increased in capacity. Advances in integrated chip (IC) chip technology reduce the amount of power required to operate newer electronic devices. The result is greater battery capacity, in smaller packages, at lower cost.

Challenges in battery pack design

When designing a portable radio, pager, cellphone or some other electronic device that requires a portable battery supply, manufacturers are faced with the following challenges regarding battery selection:

▶ *Energy density* — A manufacturer looks for the most capacity available for the specified dimensions of the battery pack. As manufacturers continue to design smaller and smaller products, the demand for a smaller battery ensues. The challenge is to provide a battery that delivers maximum power in the smallest possible package.

▶ *Weight* — Especially for portable communication devices, light weight is important. Although new lithium-based battery technology reduces weight, it does so at considerable cost. A more affordable alternative is to use new IC technology in the design of the device to reduce the required operating voltage. Accomplishing this goal makes nickel-cadmium (NiCd) and nickel-metal hydride (NiMH) battery chemistries more practical.

▶ *Cost* — A manufacturer needs to consider the cost of the battery, always an issue, in relation to the cost of the device the battery is designed to power. Especially with consumer-related products, the manufacturer must weigh the costs involved with new technologies to arrive at the most practical solution regarding the portable power supply.

Batteries for Motorola GP300 land mobile radio, incorporating flex board technology. *Multiplier Industries photo.*

Improvements in battery technology

Fortunately, developments in technology have allowed battery manufacturers to meet the growing demands of the electronics industry. For example, lithium ion (Li-ion) batteries are popular for cellular phones and portable computers because of their light weight and capacity to store energy. Although cells are expensive, lithium technology will continue to increase in popularity because of the demand for lighter weight and higher energy density.

The more-common battery chemistries, NiCd and NiMH, have advanced as well, resulting in greater ability to store energy without sacrificing size. Table 1 below illustrates the increase in available capacity for the typical AA cell during the past 10 years. As the chart indicates, technological advances have resulted in much higher battery capacity than that which

Table 1. Changes in battery capacity for typical AA dry cell chemistries, 1987–1997.

Chemistry	Capacity 1987	Capacity 1997
NiCd	450mAh	1,100mAh
NiMH	Not available	1,300mAh
Li-ion	Not available	2,000mAh

Amato is senior engineer, and Crisafulli is product manager, for Multiplier Industries, Mount Kisco, NY.

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was available only 10 years ago. New technologies are consistently being developed that will continue to increase the current capacity of NiCd and NiMH batteries.

As the power requirements of portable electronic devices diminish, and available current capacity continues to increase, the result is longer operating time for the electronic device. Therefore, the changes in technology allow a battery manufacturer to meet the demand of lower cost and smaller size without sacrificing operating time. In fact, operating time will continue to increase despite the use of fewer cells in a smaller pack because of higher available current capacity.

Just as the demand for higher current capacity is important, so is the demand for smaller size. One factor that has enabled battery size to decrease has been the development of new IC chips that are incorporated into the portable electronic device. These IC chips can operate with power requirements as low as 3V in a typical cellular phone, where the requirement was once as high as 5V. By reducing the required power levels, the number of cells required in a specific battery pack decreases. For example, the Nokia 101 cellular phone battery required six cells to deliver the required output voltage of 7.2V, whereas the new Nokia 636 battery requires only four cells to deliver the required voltage of 4.8V.

Because the number of cells required in a specific battery pack has decreased, so have the overall dimensions of the battery pack. In addition, the overall cost of the battery pack has decreased as a result of fewer cells being used in the pack. Therefore, using more-common battery chemistries, the cost of producing a portable power supply continues to decrease along with the power requirements of the electronic device.

Another method used by battery manufacturers to reduce size is to incorporate flex board (flexible printed circuit board) technology into their battery packs. A flex board takes the place of wires, weld tabs or other means of interconnect using surface-mount technology (SMT) components, which also provide a decrease in size. Flex boards provide an interconnect path within the cell pack, with an average thickness of only 0.005". Although flex board technology does not supply any critical advantage over conventional wiring in terms of connectivity, the technology does offer a size-and-space advantage.

Battery pack design factors

The key challenge for the equipment designer and manufacturer is to reduce the size and weight of the electronic device without sacrificing features or productivity. The battery manufacturer must, in turn, design and build a battery to complement the device. Keep two questions in mind:

1. What are the minimum and maximum output voltages required to power the device?
2. What is the required operating time necessary to power the device?

These two questions drive battery designers to consistently improve their products. The result has been some of the technological advances already discussed.

It is safe to say that future applications will continue to demand higher battery performance, lighter weight and longer run time. Prices of battery packs will continue to drop as fewer cells are required to deliver the voltage necessary to power

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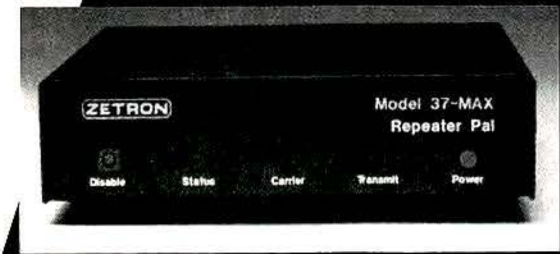

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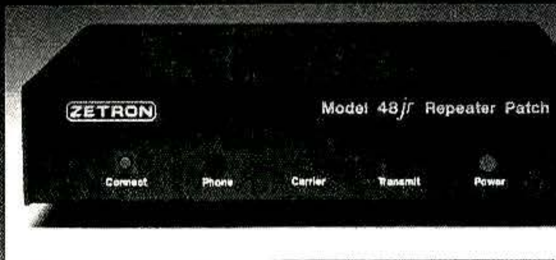

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new electronic devices. Battery capacity will continue to improve with the advent of new chemistries and with improvements to established chemistries. However, the important point is that although cell manufacturers are constantly focusing their efforts on improving their technologies, they typically react to the demands of manufacturers of electronic devices. Improvements in technology will always be driven by the manufacturer of the cellular phone, the land mobile radio, the pager or the portable computer.

When designing an electronic device that requires a portable power supply, or when evaluating a potential vendor for batteries, consider the following:

❑ The experience and reputation of a battery manufacturer is extremely important. Any company seeking a partner in a battery venture should feel comfortable with the capabilities of their battery manufacturer.

❑ The technical abilities of the battery manufacturer can be a tremendous asset when designing and developing a new battery pack. A battery manufacturer with a strong technical ability can offer valuable input regarding design and component selection.

❑ A battery manufacturer should offer impeccable engineering support to its customers.

❑ Consistency of product quality is a critical issue for a manufacturer of batteries. Look for a low product return rate, and evaluate sample products for quality of construction.

❑ Many battery manufacturers maintain a documented quality plan. This can be an excellent tool to use when evaluating potential battery vendors to determine

Improvements in technology will always be driven by the manufacturer of the cellular phone, the land mobile radio, the pager or the portable computer.

the steps taken by the vendor to ensure the quality of their products.

❑ The cost of the product is an important issue, but it is critical not to sacrifice quality over price. Bear in mind that the battery can be the most critical component of the product. A battery that delivers below-par performance can result in customer dissatisfaction and a *decrease in use of the product for which the battery is designed.*

Summary

Although requirements such as size, chemistry and cost affect battery applications, the most important factor to consider is the ability to manufacture a product of the necessary quality. A battery manufacturer should possess a thorough working knowledge of battery technology, the ability to provide valuable input regarding design and construction and the facilities and workers necessary to build the specified product.

An overview of spectrum auctions: The Devil's due

Selective application of auction authority to the land mobile community raises serious questions about the legal extent of that authority and the motivations for its use.

by Robert H. Schwaninger Jr.

Over the past six months, the Federal Communications Commission (FCC) has:

❑ announced its plans to auction licenses for "white space" (areas outside the service contours of already-licensed trunked systems) for 220MHz–222MHz.
❑ adopted rules for refarming private radio spectrum.
❑ adopted rules for auction of most of the paging spectrum.
❑ completed auctions for much of the PCS spectrum.
❑ picked up some small change on auctions of unserved cellular areas and wireless communications services (WCS).

The agency is also toying with rules to auction additional spectrum that might become available from the federal inventory.

Meanwhile, the National Association of Broadcasters (NAB) is still using references to the First Amendment to forestall any auction of broadcast spectrum; Craig McCaw is set to cut a deal to obtain valuable "free" satellite spectrum in the Teledesic deal that includes a 400MHz allocation to a single company, Associated Communications; Internet providers are posting record revenues borne from too much demand for services; and manufacturers are readying themselves for a boom in sales brought by the delivery of the new services and technologies that come to the fore daily.

It may be my imagination, but does it appear to anyone else that the land mobile community of our industry is taking it in the shorts? Does it also appear to you that the FCC cannot seem to switch its focus to other market segments to collect its tribute, giving the land mobile community a much needed breather?

Do you feel like screaming, "Enough, already!"?

Why *just* land mobile?

In the parlance of law, the term "selective enforcement" is used to negate governmental policies that are not meted out in an even-handed fashion. If a traffic cop gives tickets only to people driving red, but not blue, cars, then the cop's actions are nullified by courts, which will not countenance this type of behavior. Another example would be the FCC's use of its new auction authority almost exclusively for denying revenue to a single segment of our industry: land mobile carriers. These red cars are paying the tolls, getting the tickets, being subjected to new laws and being hauled into court with impunity by the FCC, while the blue sedans of wireline, satellite, cable TV and other segments of our industry are happily cruising down the road.

> *The FCC's use of its auction authority is employed almost exclusively for denying revenue to a single segment of our industry: land mobile carriers.*

Consider the ramifications of the 1996 Telecom Act, which allows regional Bell operating companies (RBOCs) and local exchange carriers (LECs) to go head-to-head in their markets. Some hail this statutory right to compete as a step toward greater use of competition in the marketplace, and good for consumers. But if the FCC is not using its auction authority, selectively, then where's the auction?

There is no real difference between use of spectrum and use of other means of communications, such as wireline or cable. Each is fully regulated and made possible only by a grant of authority from the agency. So, why not auction the right to compete in arenas employing this type of communications? Add to that the use of microwave channels for backbone systems, cable television's rights-of-way and satellite links, AM and FM broadcast channels, use of Global Positioning System (GPS) satellite communications, satellite "slots," old local area network (LAN) channels and more. None of these telecommunications services is facing a serious threat from the FCC's auction authority.

As long as I am spouting heresy here, I might as well go for a double slice of damnation. How about federal franchises to sell equipment, including telephones, cellphones, two-way equipment, microwave transmitters, baby monitors, GPS receivers, amateur radio sets, cable, broadcast receivers, pagers, switches, computers, and more? No one can logically argue that each sale is not dependent on the use of the federal inventory of spectrum that is being parceled out and sold in chunks to the land mobile community. So why do the equipment manufacturers get a free pass, while the land mobile carrier has to buy the hardware and buy the use of the spectrum?

Okay, we've pushed the edge of the envelope of political correctness, so let's keep marching on through. Recently, the administration announced plans to open global markets by allowing greater levels of foreign investment in domestic companies in exchange for reciprocal opportunities for

Schwaninger, *MRT's* regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC. He is a member of the Radio Club of America.

investment in foreign telecommunications services.

Where's the auction?

Personally, I would love to see an auction between British Telecom and Nippon Telephone and Telegraph for market entrance rights. We might be able to solve the deficit in the course of an afternoon and use foreign dollars to do it. (Would Sri Lanka be entitled to bidding credits?)

The point is that there isn't any auction of these extremely valuable, non-land mobile rights to compete in the marketplace, and no one is planning to hold such auctions. Imagine the political uproar if Motorola had to either bid on the right to produce pagers and end-user equipment, or else get out of the market. How about if MCI won an auction for the right to provide long-distance service that kept AT&T from expanding its services in the St. Louis basic trading area (BTA)? Or, what would happen if Digital and IBM were going head-to-head to obtain the right to produce new computing equipment? The halls of Congress would be so filled with lobbyists, the scene would resemble the Russian Revolution.

FCC Chairman Reed Hundt's plan is disingenuous in the extreme when one views the totality of the marketplace. Instead of moving the political agenda toward a new world of auctions, he has chosen only a small segment of the entire industry, specifically designed to be the most politically palatable to lawmakers. The land mobile community is quite diverse, and it comprises many smaller companies that are not wealthy enough to shake the halls of Congress. The spectrum used for land mobile is, by and large, logically licensed, and a blueprint of white space is easily (though often incorrectly) determined for the purpose of sale.

The political rhetoric is also skewed toward selective use of the FCC's auction authority. Lawmakers refer to the "public resource" of the nation's airwaves, but they give a free easement across those airwaves to the majority of the carriers. None of this wrangling focuses on rights-of-way, like those used for burying cable or construction of telephone poles, but there is no doubt that these activities also consume public resources. The precious airwaves are only seen as auction fodder when used by a specific class of carrier: land mobile companies.

Further lost in the planned agenda of auctions is the effect of being the first victims of the FCC's efforts. By subjecting land mobile carriers to the first auctions, during a period where spectrum is still viewed as "scarce" (a modifier that is quickly losing its cachet), the prices paid at auction are higher than those that will be visited upon the telecommunications industry for other uses of spectrum blocks. By the time the FCC and Congress get around to selling microwave rights, the companies participating will be paying pennies compared to the cost of starting a personal communications services (PCS) company.

Getting here

Is all of this auction activity and the timing of each new "gavel-a-thon" an accident? Yes—and no. When auction authority was provided to the FCC, Congress had decided that the federal government had more spectrum than it needed and was looking for a way to choose among competing commercial companies to use the spectrum. At the same time, PCS, the "next-generation cellular systems," were ready for market, with a lot

of well-heeled companies ready to jump into the fray, even if they had to pay dearly for that leap. Speculation was rampant, and administrative costs ran high to process "lottery ticket" applications such as those received by the thousands for rural service area (RSA) cellular licenses. The same political party controlled Congress and the Presidency, so the money raised would lower the U.S. deficit during their tenure, and they would reap the political benefits. The antitrust lawyer who assumed the chairmanship of the FCC viewed the telecommunications market as a single, amorphous conduit, without true segmentation for the purpose of ever finding market domination by any one entity. Competition was defined as an activity that goes on only among the largest, deserving entities.

The test laboratory for the FCC's new authority was decidedly small. The first auction was for interactive video data services (IVDS), which were to be a strange hybrid of home shopping and LAN use. With much ballyhoo, the FCC held its first auction, testing its systems and theories on something smaller than wideband PCS.

The result was a disaster.

The auction was over-hyped and over-sold, it was more circus than business, and Hundt looked more like a barker than a bureaucrat. More than 400 suckers were fleeced that day, many of them later to default on payments for licenses that are worth less with each passing day because equipment to serve the market is unavailable. Fortunately for the FCC, the total effect of its bamboozling of the IVDS auction participants was not fully recognized until lately, and the agency is justifying its actions by balancing its later successes against its former failure.

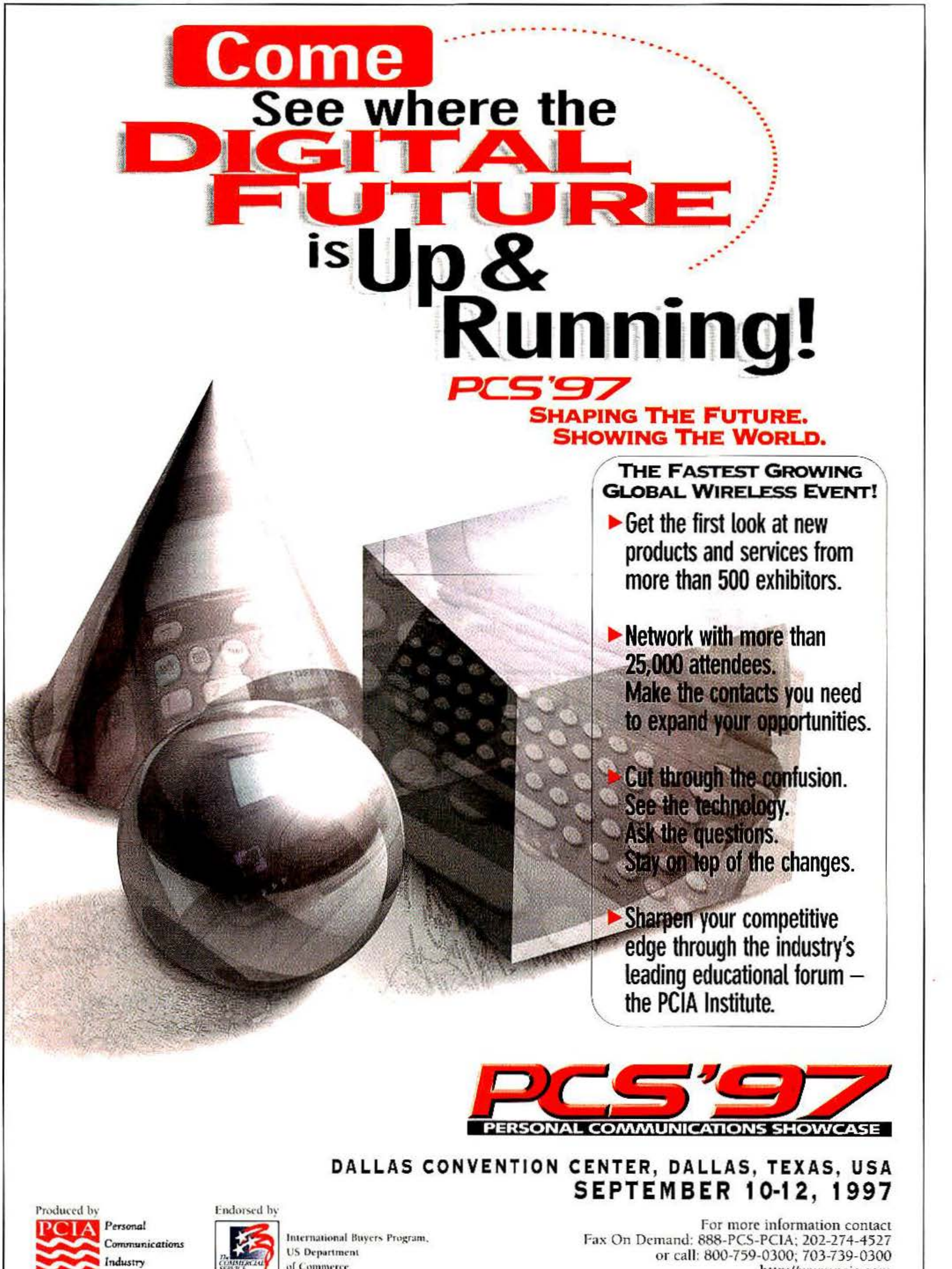
> *The FCC has spent way too much time looking at curve balls.*

Like a ball player who gets another turn at bat, the FCC stepped up to the plate with PCS wideband licenses and opened the bidding for some of the largest players in the market. Calmly, the businesslike atmosphere of the next auction proceeded until commitments for more than $7 billion were earmarked for the U.S. Treasury. Hundt took his bows for the first PCS auctions and announced that "FCC" now stood for the "federal cash cow." Congress was impressed, the administration was impressed, and every person involved in creating auction authority felt vindicated.

Although the FCC "hit it out of the park" with the first PCS auctions, its record for the remainder of the present auction agenda has not qualified it for the federal agencies' Hall of Fame. The agency is a straight-pull-hitter, socking the ball to only one side of the field: the land mobile side of the diamond. The FCC has spent way too much time looking at curve balls, like 800MHz and 220MHz SMRs, usually whiffing badly. It *has* pounded one to the warning track in the PCS C-block auctions, but the number of likely defaults caused that one to be snared before going over the wall—impressive, but a long out. It has rapped out a few hits at 900MHz specialized mobile radio (SMR) and narrowband PCS, but without any distinction. In the cellular unserved areas, it bunted.

Unsolved Problems

Meanwhile, the agency is still wrestling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with a number of problems, not the least of which is how to ensure that a game requiring substantial risk and investment from participants is open to smaller businesses. The FCC has tried bidding credits, allowing consortia, spectrum caps, installment payments and entrepreneur blocks. Still, its efforts have not truly opened the field. The FCC still has not figured out that it has the authority, under Sections 257 and 309 of the Telecommunications Act, to simply refrain from trying to force small business to participate in auctions and to employ other licensing methods. Instead, it trots out its meager victories in involving smaller companies and cites generalized statistics that mask the agency's failure. The agency even has the chutzpah to claim that the PCS C-block auction winners were small businesses. NextWave's bid, exceeding $4 billion, belies *that* characterization.

The fact is that small businesses, by and large, cannot afford to play in the auctions *and* afford to buy the equipment necessary to build the systems. To them, it is an either-or situation. Nothing the FCC has legislated to date will change that reality. Still, like a Cadillac dealer located next to a trailer park, the FCC still claims that with the right financing package each family in the park can afford the rent on their parking pad, the payment on the double-wide *and* the cost of a new Coupe DeVille.

The FCC's attempt to oversell small business is obvious when you review the costs paid by the small businesses that have participated in auction. Small business pays more for spectrum than large business, even after all of the credits, time payments and the like are taken into consideration. The effects of the FCC's actions have created a *disincentive* for small business growth, despite alleged best efforts.

> *Another issue that is beginning to cause greater problems for the FCC is 'spectrum warehousing.'*

Mothballed megahertz

Another issue that is beginning to cause greater problems for the FCC is "spectrum warehousing." While the FCC continues to put bigger blocks of spectrum on the auction block, the issue of when (and if) the winners will put that spectrum to use arises. For example, does a PCS operator with 30MHz of spectrum need *all* of it to provide service to the public? Probably not, at least for the foreseeable future. So, does the agency have the responsibility to limit the size of the allocations or to adopt rules to assure the spectrum's future use? Many people who have witnessed the high-definition television (HDTV) mess have begun to adopt a "use it or lose it" attitude that is gaining momentum. The FCC is ducking this question by claiming that winners have an "economic incentive" to use that for which they have paid.

Reasonable persons may differ with this rosy view.

Droit du seigneur

A huge, looming issue is the extent of the FCC's authority in employing auctions. As the agency has moved to auction "white space," the language of Section 309 of the Telecommunications Act has become ripe for judicial interpretation. The language of the Act says that the FCC

is to use auction authority as a remedy to decide among mutually exclusive applications. The Act does not suggest that the agency has the right to *cause* the mutual exclusivity first (i.e., by announcing a bidding war) for the purpose of employing the remedy. The agency's obvious bootstrapping of its auction authority is likely to come under fire, and the courts will decide if the FCC has the broad authority that it has claimed, unchallenged, to date.

Procedures

So far, the FCC's processes are obviously intended to wring the last dollar out of the bidders. Simultaneous, multimarket, multichannel, multimillion-dollar bidding procedures make participation expensive. These procedures invite speculation, bid parking and a host of ills that do not result in awarding licenses to sincere participants that desire to deliver a specific service within a specific market.

Finally, there are charges that the agency uses auctions solely for the purpose of raising revenue, and that this motivation controls decisions regarding when, where and how to hold an auction. The FCC was directed by Congress, within the specific language of the Telecommunications Act, *not* to use revenue collection as its primary motivation in creating and administering auctions. Few could seriously say that the "federal cash cow" has not either ignored or failed to take this statutory admonition seriously.

The FCC's greatest abuse of its auction authority is still selectivity.

Progress and problems to date

The short history of the FCC's use of its auction authority has been a checkered one. The agency's authority has netted some positive effects for the industry and the American public, but the greater number of examples demonstrate the agency's inability to employ that authority in a manner that produces the effects visualized by Congress. The federal lawmakers wanted money to be raised, but not at the expense of small business opportunity. Congress wanted a return on its investment in regulating telecommunications, but the agency has limited that return by including only land mobile operators in the universe of auction participants.

The Chairman has flip-flopped on auction of broadcast spectrum, adding to the confusion; has ignored the issue of warehousing (or declared that it is not really so bad); has been willing to disrupt whole market segments simply to enjoy another auction; and has yet to articulate a realistic approach to rural telephone companies, small business, minority participation, manufacturers, private radio licensees, incumbent carriers or foreign involvement. Undeterred, the FCC has plunged forward into the icy auction waters, holding its breath and hoping the financial bottom is deep enough to forestall stricter guidelines from Congress.

The FCC's greatest abuse of its auction authority is still the first one discussed—selectivity. The industry might take the FCC more seriously if a bid had been let for the right to provide the 1-900 service for conducting auctions. At least that would have demonstrated some fairness, which is sorely needed.

(continued from page 8)

Table 1. How site noise affects line loss and the use of a tower-top amplifier.

Line	N_{ANT} (dB)	PREAMP	L_{LOSS} (dB)	N_{RX} (dB)	N_{SYS} (dB)
1	3	NO	0	9	9.5
2	3	NO	1.5	9	10.9
3	3	NO	3.0	9	12.3
4	3	NO	6	9	15.1
5	10	NO	0	9	12.3
6	10	NO	2	9	13.3
7	10	NO	4	9	14.6
8	10	NO	6	9	16.1
9	20	NO	0	9	20.3
10	20	NO	3	9	20.6
11	20	NO	6	9	21.2
12	3	NO	0	9	9.5
13	3	YES	0	9	4.2
14	3	YES	3	9	4.6
15	3	YES	6	9	5.3
16	10	NO	0	9	12.3
17	10	YES	0	9	10.3
18	10	YES	3	9	10.4
19	10	NO	3	9	14.0
20	20	NO	0	9	20.3
21	20	NO	3	9	20.6
22	20	YES	3	9	20.0

line loss of 0dB is 20.3dB (line 9). The overall system noise figure for 6dB line loss only increases by 0.9dB. Thus, with high site noise, the line loss is less significant than where site noise is low.

Lines 12–15 illustrate the effect of a tower-top preamplifier at a site where the ambient noise level is at an absolute minimum. On line 12, no preamplifier is used, and the overall system noise figure is 9.5dB for a line loss of 0dB. On line 13, a preamplifier is used (line loss still 0dB), and the system noise figure is reduced to 4.2dB. This represents an improvement of 5.3dB in the system noise figure—a significant improvement. On line 14, the line loss is increased to 3dB and with the preamplifier in place, the system noise figure only increases by 0.4dB. Thus, the preamplifier does an excellent job in improving the system performance in the presence of low site noise. Even with a 6dB line loss (line 15), the system noise figure is only 5.3dB.

Lines 16–19 show how a preamplifier affects system performance in moderate site noise levels. With a 10dB antenna noise figure and 0dB line loss, the system noise figure is 12.3dB without the preamplifier. With the preamplifier in line, the system noise figure is improved by only 2dB (line 17). If the line loss is increased by 3dB (line 18), the system noise figure only increases by 0.1dB.

Lines 20–22 show how system performance is affected by a preamplifier in a high site noise environment. On line 20, the preamplifier is not in line, and with 0dB line loss, the system noise figure is 20.3dB. If the line loss is increased to 3dB and still no preamplifier is in line, the system noise figure is 20.6dB. Line loss has little effect. On line 22, the preamplifier is inserted in line, and with 3dB line loss the system noise figure is 20.0dB. This represents an improvement of only 0.6dB compared to line 21, where the preamplifier was not in line. From this, it is obvious that a preamplifier is of little value at communication sites where the ambient noise level is quite high.

It is also apparent that in high ambient site noise, small line losses have little effect on the overall system performance. This would include insertion losses of cavity

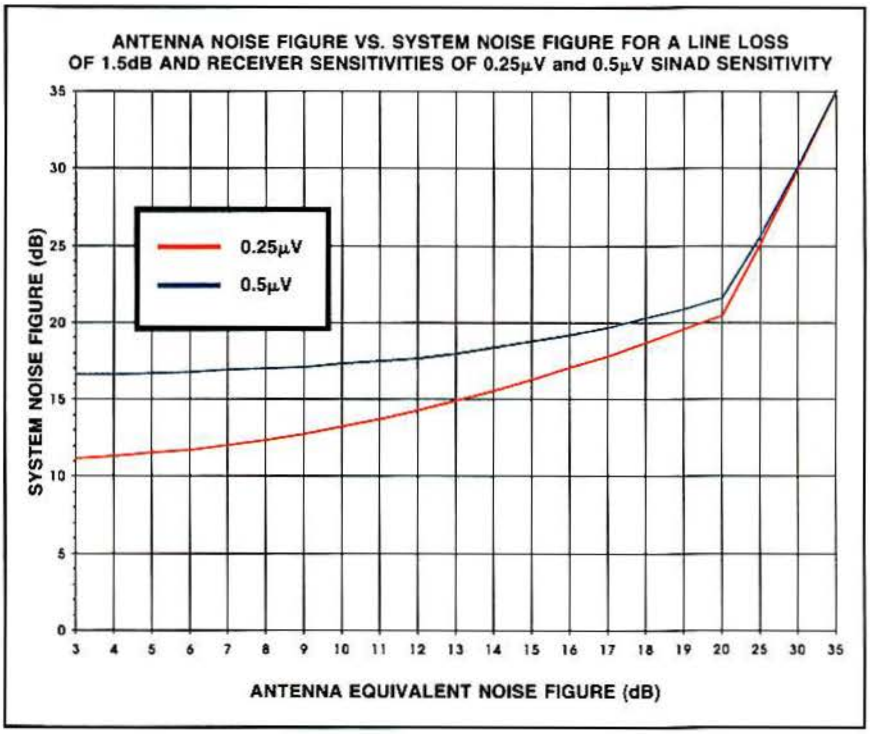

Figure 4. Plot of a receiver with a sensitivity of 0.25mV (red), compared to the plot of a receiver with a sensitivity of 0.5µV (blue).

filters and other insertion losses as well.

The isotee test

Suppose you perform an on-site test with the isotee to discover just how much site noise is degrading your receiving system. Suppose that you measure a degradation of 20dB with the antenna connected vs. the dummy load. Study the graph in Figure 4 above. This graph is for a receive system with a line loss of 1.5dB. The blue graph represents a receiver with a 12dB SINAD sensitivity of 0.5µV, and the red graph represents a receiver with a 12dB SINAD sensitivity of 0.25µV.

Now, if our isotee measurement were to indicate a degradation of 20dB with the antenna connected, the system noise figure would have been degraded by 20dB. Add the 20dB to the point of the vertical scale where the red graph intersects. Thus, 20dB plus 11dB = 31dB. Move up to 31dB on the vertical scale and over to the red graph and down to the horizontal scale, and we find the antenna has an equivalent noise figure of 31dB. If the external noise is reduced by 20dB so that the equivalent antenna noise figure is 11dB, then the overall system noise figure will increase less than 3dB. Move down the horizontal scale from 31dB to 11dB, up to the red graph and over to the vertical scale to about 13.5dB for the new system noise figure. Suppression of the noise much below this level will yield little improvement.

Summary

Remember, site noise from several sources adds as the *root-sum-square* for non-coherent noise voltages. If a certain transmitter is degrading your system, it will do no good to suppress that source of noise much below the noise level of the general noise floor at the site. To be sure you are attacking the problem at the correct transmitter, observe the difference in noise degradation with the suspect transmitter up and down.

When the equivalent antenna noise figure is high, suppressing the noise level by approximately 6dB *plus* the amount of degradation will yield about the best improvement.

Further suppression will be of little benefit.

Until next time—*stay tuned!*

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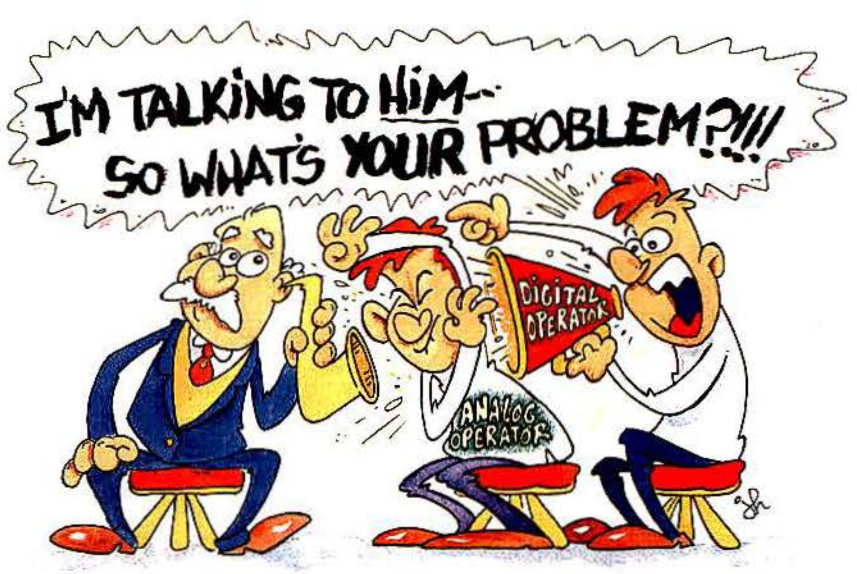
Taking responsibility for harmful interference

By Robert H. Schwaninger Jr.



My conversations with operators around the country reveal that incidents of harmful electrical interference are on the rise. Some operators report that they are spending two days a week tracking down sources of harmful interference and trying to clean up the spectrum. Although the causes vary somewhat, the question remains, what is the FCC doing about it? The answer is, sadly, bupkis.

Remember the old days, when the FCC at least gave the *appearance* of wanting to help? Old FCC field office records gave the impression that a fleet of vans would encircle the offender like a pack of sharks, DF dorsal fins breaking the sky, and pounce upon the interfering facility with demands for immediate inspection and correction.

This enforcement was sometimes viewed as intrusive by otherwise well-meaning operators whose systems had slipped their tuning, or whose systems were sending spurious signals that the operators hadn't detected. The presence of the FCC served as a necessary impetus for operators to do *something*, and do it *quickly*.

Schwaninger, *MRT's* regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC. He is a member of the Radio Club of America.

The problem is so basic that it gets few headlines, and that's the reason why it has been allowed to get worse. Today, the FCC is "Broadway," with shows, critics, plots, characters and stars. Nobody wants to talk about gum under the seats while the actors are performing. Rather than keeping order so the industry can do its thing on stage, the ushers—the regulators—have become part of the act.

Digital masking rules

This publication has the word "Technology" in the title and, judging by the rest of the editorial content, the other writers are much more qualified than some cheesy lawyer to speak on technical issues. But speaking on behalf of cheesy lawyers (Our meetings require the entire state of Kansas, where there's plenty of standing room.), we sometimes notice things first.

During the past few years, analog operators have been complaining about adjacent-channel digital systems, that broadcast signals with square wave configurations that are often incompatible with adjacent analog operations. The square wave overlaps the analog sine wave, and the energy pulsed into the adjacent analog wave desensitizes the analog receiver, which is attempting to capture the entire analog wave.

When this phenomenon is discovered by analog operators and is pointed out to digital operators, some of them respond with

> *The truth is that it is the digital operator's problem, particularly in view of the FCC rules that require operators to take reasonable precautions to prevent harmful interference.*

"Our equipment is operating according to specs." This translates roughly into, "It's your problem"—an interesting approach to spectrum management. (An approach that sometimes is mirrored by the FCC.)

The truth is that it is the digital operator's problem, particularly in view of the FCC rules that require operators to take reasonable precautions to prevent harmful interference. Although operating a digital system with type-accepted equipment might be a good start in meeting the rules, the *method of operation* is as important as the *equipment used*. Therefore, if an operator knows that his system is causing harmful interference because of a system design that includes selecting the location and power used for each transmit frequency within a multichannel digital system, the creator of the problem has the burden of finding a solution.

Most of these situations that were resolved (and many are still ongoing) were fixed by the digital operator implementing a different frequency use plan or adding filtering. In other words, "Good fences make good neighbors," but where this problem continues unabated, it can be severely disrupting to operators and cause numerous headaches for customers of the analog systems. So what is the better answer?

In Washington, DC, a place where few answers are found, one group is gathering information for the purpose of proposing rules to be adopted by the FCC regarding the operation of digital systems adjacent

to analog systems. The object is to update the "masking rules" for digital operations. *Masking* refers to the distribution of radio energy within a frequency channel. The less energy there is that extends to the channel edges, the less likely it is to interfere with adjacent channels. The current masking rules for some services are the same for both analog and digital operations. Therefore, when an operator makes the switch from analog to digital, he is allowed to use the same masking rules.

If more practical masking rules were adopted, digital and analog operators could live in better harmony, without the increasing spectrum chafe. Of course, this would require some *enforcement* of the new rules by the FCC—which might be hoping for too much. At least a new masking requirement might cause equipment to be built that would be more compatible within the actual operating environment.

In praise of filters

Another source of the interference problem is the failure by technicians to install filters. This problem is seen quite often in the installation of additional channels on 900MHz paging tranmsitters. The carrier wants to use a single transmitter to meet its construction requirement for multiple paging frequencies. The technician is directed to install the additional channels, but neglects to install additional filters to upgrade the transmitter into "good neighbor" status for the use of the additional frequencies.

The failure to install the filters creates a sloppy signal that splashes over the band and onto adjacent channel systems. Bingo! Harmful interference is caused that is difficult for the operators of adjacent-channel systems to pinpoint—and even more difficult for them to explain to the offending carrier.

If more practical masking rules were adopted, digital and analog operators could live in better harmony,

Although most readers of this publication like to think of themselves as RF professionals, the truth is that you often might be harassed by your company's executives and marketing managers to "Get it done today," even if today you lack the filters necessary to do the job right. You know when the channels are being installed that they might cause a problem without proper filters. Yet, sometimes you do the job you are paid to do, rather than the one you know is correct.

To solve this problem takes professionalism and ethics. RF engineers and technicians must expand their vision to consider not only how their systems are working, but how the operation of their systems might affect others.

Tell me more

If you want to help solve the increasing incidents of harmful electrical interference, your input is sorely needed. You know the "whys" and the "hows" better than anyone inside the FCC because you have to live with the problems every day. Please send your stories, solutions, technical observations, and suggestions to me, Robert Schwaninger at 1835 K Street, Suite 650, Washington DC 20006, or fax it to 202-659-0071. I'll pass it on to the group working on the problem.

Motorola aids in North Dakota flood recovery effort

Motorola technician, Elie Khoury, working in the Schaumburg, IL, facility, puts together a repeater for the infrastructure of a five-channel trunked radio system loaned to North Dakota to help coordinate recovery and relief efforts.

Motorola Land Mobile Products Sector donated the use of two mobile wireless communications units to North Dakota flood recovery efforts this spring. Use of the trailers helped coordinate two-way communications for thousands of public safety and emergency workers for national, state and local agencies.

North Dakota was one of the hardest-hit with floods this past spring after record amounts of snow and ice melted, followed by spring rains.

Pete Eggimann, director for Grand Forks County's Public Safety Answering Point (PSAP) said. "During the evacuation, we were able to use our existing two-way radio systems with portable equipment with limited capabilities. Once the floods hit, however, the PSAP was shut down, moved three times, and we could not communicate effectively outside our own groups."

Each unit contained an 800MHz, five-channel StartSite trunked system. These systems each supported as many as 500 two-way radio users and provided for multiple, autonomous talk groups. Each had a 50', hydraulically extendible antenna mast for wide-area communications and was powered by a self-contained 10,000W diesel generator. More than 200 Motorola MCS2000 mobile radios were loaned to the relief workers communicating on the network.

FCC Chairman Reed Hundt resigns

FCC Chairman Reed Hundt turned in his letter of resignation on May 27, 1997, citing the need to spend more time with his wife and children as the reason behind his decision. He asked President Clinton in a letter to begin the process of selecting his successor. Hundt will continue to serve as chairman of the FCC until Clinton appoints a new chairman. Hundt has been chairman for three and a half years. The term to which he was appointed ends June 30, 1998.

IWCE sets new domestic, international attendance records in 1997

The recent production of the International Wireless Communications Expo (IWCE), held April 22–24 at the Sands Expo Center in Las Vegas, established new attendance records for the 21-year-old event. Registration reached 10,642 by the close of the final show day, marking a 6% increase over the previous year (which was also a record-breaker).

International attendance soared by even larger percentages—1,395 mobile communicants professionals from 86 foreign countries made the trip to Las Vegas for IWCE—a 21% increase over the previous year.

Exhibitor participation also surpassed all previous records—342 exhibiting companies occupied 894 booths in 1997, compared to 865 booths in 1996.

News

Kenwood licenses dc/MA technology, opens sales office

Kenwood Communications, Long Beach, CA, will license Unique Wireless Developments' dc/MA technology. The technology will be implemented in the 800MHz SMR and ESMR frequency band, allowing a five times voice capacity improvement per existing 25kHz channel. This new technology could also be applied to other frequency bands, and discussions are under way to take advantage of these additional opportunities. The technology is compatible with existing FM equipment and has a low cost for conversion or migration of existing systems.

The new equipment can be made compatible with traditional SMR equipment that uses a single-site, high-powered architecture. Operators will also be able to upgrade a single channel at a time, rather than having to replace entire systems.

Kenwood Communications has opened an international sales facility in Miami. The offices, located at 11430 SW 88th St., serve as the marketing center for sales in international regions, with particular emphasis on Latin America.

American Tower Systems acquires Towers

American Tower Systems, Boca Raton, FL, a wholly owned subsidiary of American Radio Systems, Boston, has entered into an agreement to acquire the assets of Towers, L.L.C. Columbia, SC, for $5.3 million. Towers owns and operates 21 tower sites in South Carolina.

Ken Hall, the former president of Towers, joined ATS as the southern regional manager. American Tower Systems plans to continue to develop tower sites in South Carolina and adjacent southern states.

Chadmoore Wireless affected by two separate construction rulings

Chadmoore Wireless Group, Las Vegas, received notice about two separate actions on May 20 from the Federal Communications Commission and the United States Court of Appeals, effectively denying grants of additional time for station construction.

The FCC decision denied an original five-year extension to Chadmoore to conclude construction. This extension had been granted in May 1995 to Chadmoore's more than 5,000 stations but had to be justified in December 1995. A favorable ruling for Chadmoore would have granted two years, or the balance of the original five-year extension. The new decision requires that all of the affected stations be constructed within six months of May 20. The licensees of the affected stations, with the cooperation of Chadmoore, intend to petition the FCC to reconsider its decision and to stall the construction deadline during the period of reconsideration.

The separate action by the U.S. Court of Appeals affirmed the FCC's December 1995 denial of Chadmoore's request for a grant of an extended amount of time to construct 2,300 additional stations. However, most of the stations affected by the court's decisions are included in an extension of the original construction deadline granted to Daniel R. Goodman and Robert Chan. The "Goodman-Chan" extension grants these stations a construction period that will end four months after publication in the Federal Register. The extension was granted on May 24, 1995, and as of May 23, 1997, had not been published in the Federal Register.

Businesses get Signal from Motorola

In an effort to better serve customers with its wireless communications systems in the south Florida market, Motorola will begin transferring its select service accounts to Signal Communications Service, Pompano Beach, FL, the authorized Motorola Service Station (MSS) in south Florida. The MSS designation was awarded to Signal in January 1996. During the next 12 months, a select group of expiring Motorola service contracts associated with businesses in south Florida are to be converted to Signal contracts.

Last year, Signal was selected by Motorola to purchase three Motorola service centers in Dade, Broward and Palm Beach counties after serving as a charter distributor for five years. The arrangement is part of Motorola's continuing plan to focus on larger business sectors while converting small- to medium-size contracts to local authorized MSS.

PageMart growth plan raises subscriber base to 2 million

PageMart Wireless, Dallas, has announced record growth of its subscriber base. It has attained two million subscribers less than two years after hitting the one-million-subscriber mark. The milestones were achieved through internal efforts as opposed to growth through mergers and acquisitions.

John D. Beletic, president of PageMart, attributes the company's growth to its long-term operational blueprint. Components of the strategic growth plan include deployment of a direct broadcast satellite system, formation of strategic alliances with telecommunications industry giants and development of a national retail channel. The PageMart network's footprint was expanded as well to ensure consistent operability and NAFTA-wide seamless roaming through its common frequency network.

News

Coded Communications, Racom join to provide wireless communications for public safety in Iowa

Coded Communications, Carlsbad, CA, has partnered with Racom, Cleveland, to enable public safety fleets throughout Iowa to access various law enforcement databases, broadcast their positions and file reports electronically.

Coded and Racom will share the revenues derived through the use of the system. Coded also has granted Racom the right to market Coded's in-vehicle mobile data communications equipment and software products to other potential customers.

Through the joint system in Iowa:

❑ State and local police officers on patrol can access critical information from the NCIC, DMV and local or regional databases. Requests that could have taken as long as 20 minutes will take only seconds.

❑ Fire departments can incorporate sophisticated map graphics and database information retrieval to cut response times.

❑ Emergency medical service providers can cut critical response time by incorporating GPS automatic vehicle location options in their mobile data systems.

Boeing to build Teledesic's 'Internet-in-the-sky'

The Boeing Company, Seattle, will become an equity partner in Teledesic, Kirkland, WA, and serve as the prime contractor for the company's global, broadband "Internet-in-the-sky."

Boeing will invest as much as $100 million for 10% of the current ownership of Teledesic. As the prime contractor, Boeing will lead an international effort to design, build and launch the Teledesic Network. The estimated contract value is $9 billion. Using a constellation of several hundred low-Earth-orbit (LEO) satellites, Boeing and Teledesic will create "fiber-like" access to telecommunications services such as broadband Internet access, videoconferencing and interactive multimedia.

The Teledesic Network will provide switched, broadband network connections through service partners in host countries worldwide. The network emulates the Internet, while adding the benefits of high-quality service and location-insensitive access. Service is expected to begin in 2002. With the network, enterprises will be able to connect branch offices throughout the world to their existing global networks, and workers will be able to telecommute from anywhere.

Teledesic's satellites will orbit about 50 times closer to Earth than traditional geostationary satellites. The network's low orbit eliminates the long signal delay normally experienced in satellite communications and enables the use of small, low-power terminals and antennas, about the size of direct broadcast satellite (DBS) dishes.

Batteries Batteries buys cellular accessories distributor

Batteries Batteries, New York, has acquired the assets and business of Cliffco of Tampa Bay, a privately held nationwide distributor of cellular telephone accessories.

Cliffco is also a distributor of batteries. It generated revenues of $5 million in 1996.

The transaction was completed in exchange for 193,500 shares of Batteries Batteries stock and $75,000. David Costilow, president of Cliffco, will retain his title at Batteries Batteries under a long-term incentive employment agreement. Cliffco plans to relocate to built-to-suit 19,000 square-foot offices and warehouse in the third quarter of this year.

Product/Logo Directory

Advanced Systems
ASC manufactures and sells two-way MicroTalk & Tech-Talk VHF and UHF portable radios and accessories. ASC is now a major distributor of many types of batteries and cellular phone accessories.
Circle (301) on Fast Fact Card

Aerotron-Repco Systems
Manufacturers of FM radio products for data and voice communications. Products include a wide range of trunking, spread-spectrum modems, transmitters, receivers and base station/repeaters.
Circle (302) on Fast Fact Card

Avtec
DSPatch & DSPatch 32 are digitally switched integrated radio or telephone console systems with color touchscreen or mouse operation. Used by railroads, transit authorities and airlines, the consoles are designed for applications for public safety, utilities, military and other government agencies worldwide.
Circle (303) on Fast Fact Card

BIRD Electronic Corporation
A Member of Bird Technologies Group

Bird Electronic
Bird's new line of 50Ω, air-cooled RF loads and bidirectional attenuators include 2W through 300W models. Standard attenuation values are 1dB, 2dB, 3dB, 6dB, 10dB, 20dB and 30dB.
Circle (304) on Fast Fact Card

CELWAVE®
DIVISION OF RADIO FREQUENCY SYSTEMS INC.

Celwave
ESMR, cellular and paging carriers now have a new way to optimize their systems. The Optimizer is a log periodic dipole antenna that permits continuous adjustment of electrical downtilt from 0° to 14° with the simple turn of a dial.
Circle (305) on Fast Fact Card

COMMUNICATIONS SPECIALISTS, INC.
(800) 854-0547

Communications Specialists
Communications Specialists' line of tone signaling products include CTCSS, DPL and two-tone sequential encoders and decoders, automatic Morse station identifier, shared repeater tone panels, SMD prototype kits and a new microminiature ANI encoder.
Circle (306) on Fast Fact Card

Leavitt Communications
Leavitt Communications is a Motorola authorized paging and Pinnacle Club dealer. They can provide all Motorola paging products, as well as Motorola Radius radio products.
Circle (307) on Fast Fact Card

MAXRAD
STATE OF THE ART ANTENNAS

Maxrad
Maxrad is a premier supplier of antennas for the communications industry. From Hanover Park, IL, the company manufactures a full line of mobile, portable and base station antennas. Ranging in frequencies from 27MHz to 2.6GHz, Maxrad has antennas for all communications needs.
Circle (308) on Fast Fact Card

OPTOELECTRONICS

Optoelectronics
Manufacturer of nearfield test receivers, frequency recorders, frequency counters and tone decoders. Test two-way radios for frequency, audio, deviation, signal strength and CTCSS/DCS/DTMF.
Circle (309) on Fast Fact Card

Otto Communications
Otto Communications is an ISO 9001-registered

manufacturer that specializes in communication accessories for the two-way radio market. Otto's product line includes remote speaker microphones, lightweight headsets, heavy-duty headsets, low-profile earphone kits and numerous other standard or custom accessories. Compatible with a variety of radios.

Circle (310) on Fast Fact Card

Selectone

Selectone manufactures a full line of voice encryption products; tone signaling products, which include CTCSS, DTMF and two-tone sequential boards; and ANI (automatic number identification) products.

Circle (311) on Fast Fact Card

ServiceWare

ServiceWare provides ServicePlus service information systems to high technology electronics field and depot repair industries globally. ServicePlus series 3 is a full 32-bit Windows version. ServiceWare provides implementation and training services, as well as high-quality customer and product support.

Circle (312) on Fast Fact Card

TESSCO

TESSCO is a leading supplier to the mobile dispatch, cellular, paging and PCS markets, offering express delivery and support for more than 17,000 products from more than 270 major manufacturers. A buyers' guide and Magic procurement software are available on a complimentary basis to qualified service organizations.

Circle (313) on Fast Fact Card

TRL Technologies

RF design consultants to the wireless industry with expertise in analog and digital amplifier design; amplifier linearization techniques; cellular, PCS & wireless local loop development; RF boosters, repeaters, cell enhancers and in-building solutions.

Circle (314) on Fast Fact Card

Trylon-TSF

Trylon-TSF is a full-service provider for the wireless industry offering tower design, manufacturing, tower installation and civil works. Trylon-TSF's technical services division offers building installation, radio installation, antenna supply, testing, sweeping and commissioning.

Circle (315) on Fast Fact Card

Thunder Eagle

Thunder Eagle's patented weather alert scanning and recording receivers automatically place weather alerts on a two-way radio system, voice mail system or pager.

Circle (316) on Fast Fact Card

Times Microwave Systems

Times Microwave Systems develops and manufactures coaxial cables and assemblies, including LMR cables designed for better flexibility, resistance to kinking, comparable attenuation and easier connector attachment at a lower cost.

Circle (317) on Fast Fact Card

VoCom

VoCom designs and manufactures high-quality RF power amplifiers for paging, two-way, trunking, repeater and base station applications, 30MHz–960MHz.

Circle (318) on Fast Fact Card

Readers' choice

Of all the new products and services in the November 1996 issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them. Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

Mobile computer mount includes slide tracks for easy installation

A locking laptop computer mount featuring a quick-release latch is part of the Consolidator series of vehicle consoles and mounts from **Havis Shields Equipment**. The computer mount is one component in a series designed to simplify installations by bolting equipment to slide tracks recessed in the top of the base.

Circle (500) on Fast Fact Card

Tone encoder upgrade gives direct LED display of frequency

Communications Specialists' upgraded version of its TE-64D tone encoder is a multipurpose CTCSS/burst unit that displays the tone frequency on a four-digit LED. The self-contained, fully enclosed encoder provides all EIA CTCSS tones from 67.0Hz to 203.5Hz and all common burst tones from 1,600Hz to 2,550Hz in 50Hz increments. A front dial rotary switch provides tone selection for mobile applications, night operations or other situations requiring high-visibility readout. Frequency accuracy is 0.1Hz for subaudible and 1.0Hz for audible tones.

Circle (501) on Fast Fact Card

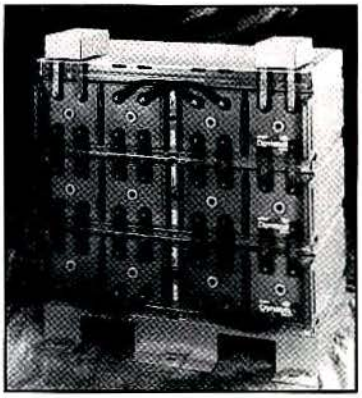
Remote site equipment monitor handles 8 transmitters, antennas

The DB 8860 Sentry from the **Decibel Products division** of **Allen Telecom Group** is a modular, low-cost system designed to monitor and control site equipment of trunked, conventional, paging, cellular, IMTS, mobile radio dispatch and aviation systems from 30MHz to 1,000MHz. The monitor can handle from one to eight transmitters and antennas and, with an expansion slave unit, expands to handle as many as 32 transmitters and antennas. The basic system has four separate ports, each providing four analog and two digital inputs that are user-definable. Also included with each port are one Form C relay output, one relay driver and one balanced audio pass-through. The main system also provides for eight additional digital inputs and four additional Form C relay outputs.

Circle (401) on Fast Fact Card

New products

DDH battery incorporates improved VRLA design



Yuasa-Exide has improved valve-regulated, lead-acid battery (VRLA) design for telecommunication applications with its DDH battery. The DDH battery features a large ampere-hour plate (125Ah). The DDH VRLA battery uses Yuasa-Exide's absorbed glass mat (AGM) technology and ranges in capacity from 120Ah to 4,000Ah in 24V or 48V configurations. Capacity is 2,000Ah in non-paralleled configuration. Reduced height and length allow configurations in any 19", 23" or 30" relay rack. The Slide-Lock seal allows plates to grow without stressing the cover or post seal, thereby reducing the occurrence of cracking covers or leaking posts caused by plate growth. The Skate-Key locking device enables users to tighten the fit of DDH batteries within modules, thereby increasing compression and lengthening service life. Users can also loosen the fit enough to permit easy removal of these modular cells.

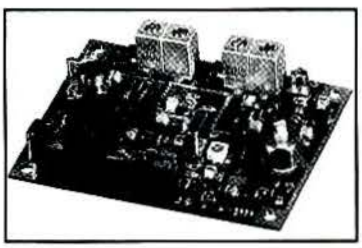
Circle (402) on Fast Fact Card

RMS data loggers automatically adjust scale and sample rate

The Simple Logger family of RMS data loggers from **AEMC Instruments** requires no user set-up and can automatically adjust its scale and sample rate to optimize the recording. One-button operation makes this data logger easy and quick to use. A Windows-based software package is included, which allows plotting, statistical analysis, text annotation and zoom capability. Graphs and tabular listings can be printed. Graphs can also be pasted to the Windows clipboard for insertion into other programs. Stored files can be imported by all popular spreadsheet programs. Other features of the data logger include one-year operation from single 9V alkaline battery; storage of more than 8,000 data points, built-in RS-232 port for downloading; compact size ($2^7/_8$" × $2^5/_8$" × $1^5/_{16}$"); available inputs including Arms, Vrms and temperature.

Circle (403) on Fast Fact Card

UHF transceiver design supports high-speed data, duty cycle operation



RF Industries' Neulink Division's DCL-SYNX-U is a synthesized, transceiver, operating in the UHF band, 403MHz–512MHz. Designed for high-speed data applications and 100% duty cycle operation, the DCL-SYNX-U is a direct replacement for the DL 3472. The transceiver can be integrated with the Neulink modem, Neumodem 9600 to provide a high-speed, intelligent transceiver modem, the Neulink 9600.

Circle (404) on Fast Fact Card

Remote speaker microphones withstand harsh conditions

The V2 series of remote speaker microphones from ***Otto Communications*** are compatible with a variety of radios, which are listed in the V2 series selection guide. The microphones feature durable construction to meet MIL-STD-810E specifications. The housing is fully sealed. The mics also have a heavy-duty cable assembly with strain relief for demanding applications and two-position volume control for operation in various noise environments. The V2 includes an earphone jack that accepts standard 2.5mm plugs, and it has a flexible design to fit most portable radio configurations.

Circle (405) on Fast Fact Card

Measurement system surveys pilot channel signals, reports power profiles

The Scout from ***Berkeley Varitronics Systems*** is a mobile measurement system that continuously surveys all the cellular or PCS CDMA pilot channel signals and reports their power profiles. These profiles indicate the distribution of interference and multipath components as a function of relative power and delay. The system uses an eight-channel GPS system to synchronize and track the CDMA signals. The Scout can be configured to survey all or specific base stations. The system conducts CDMA coverage studies, base station transmitter testing and setting hand-off thresholds. The output of raw data from the Scout may be coupled with any standard propagation and multipath fading analysis software.

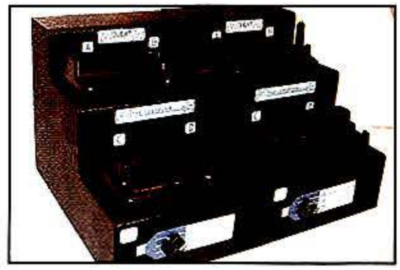
Circle (406) on Fast Fact Card

Paging terminal system performs message delivery

The Prism II paging terminal system from ***TGA Systems*** comprises a series of functional modules. Each module performs a part of the overall task of message delivery. The processor is the basic building block for the system. The processor uses a passive backplane design, allowing multiple vendors of processor and other support cards. The modular structure permits the operator to maintain growth as technologies and service levels change over the life of the system. Processors are based on the Intel 486 DX series family and use a high-speed video and peripheral bus on the processor engine board. The system uses the Intel iRMX real-time, multi-tasking operating system to process high volumes of traffic.

Circle (407) on Fast Fact Card

Control system accesses several pager programmers



The Codifier from ***Ducat Industries*** is a pager programmer control system that provides quick access to any programmer, eliminates tangled wires and can be used with existing Motorola programmers. The system features strong ABS plastic construction and is designed for use with any computer system. One base unit holds as many as four pager programmers, and the Codifier system allows base units to be interconnected. Model A will hold programmers for Bravo Tone, Bravo Alpha, Keynote and Universal Interface. Model B supports a wide variety of programmers, including Bravo Lifestyle Plus, Advisor and Encore.

Circle (408) on Fast Fact Card

Repeaters come data-ready with several modem options

The ETR5000 Gold rack-mount base stations and repeaters from ***ETrunk Systems*** have microprocessors that monitor, display and adjust all levels of the radio operating parameters. The RF power can be adjusted via the diagnostic port and can provide the ability to select channels as well. A PC program is available to provide a full display of all information involved in servicing or programming the unit. All Gold series repeaters come data-ready. Several modem options are available for use as a dedicated data radio or as a shared voice radio. The ETR5000V/VH/U software can switch from pre-emphasized voice use to flat data use "on the fly." An integrated CTCSS/DCS tone panel is available as a plug-in option. A 2400-baud MSK modem is also available in the integrated tone panel. A special option board enables the ETR5000 series to operate as a rural telephone system using the EDTS digital trunking protocol. The radio is provided with a two-wire, end-to-end telephone interface to allow wireless local loop operation over extended distances.

Circle (409) on Fast Fact Card

Catalog features smaller modules

Midian Electronics' *1997 Catalog* has 13 color pages of communications products including automatic number identification, encoders, decoders, scramblers, CAD systems, adapters, remote control products, accessory products and more. Midian has redesigned its modules into smaller, thinner sizes with a microminiature quick disconnect plug with color-coded leads. All are included in the catalog.

Circle (421) on Fast Fact Card

Site planning guide serves infrastructure product buyers

TESSCO's *Site Planning Guide* is a consolidated source book of information needed for site construction, maintenance and repair. The guide catalogs the offerings of dozens of manufacturers by product type including antennas, cable, jumper assemblies, connectors, hanger kits, ground bars, weatherproofing kits, hoisting kits, grounding kits, site hardware, lightning protection and filter equipment. The 28-page guide contains several site planning worksheets and is formatted to fit in a briefcase or glove compartment.

Circle (422) on Fast Fact Card

Tower lighting controls application guide cross-references products

SSAC's "Tower and Obstruction Lighting Controls Application Guide" is a 16-page application and product selection guide. It has been expanded to include lamp outage and beacon flasher monitoring relays. The guide cross-references products and applications. Included are controls for beacon flashing, synchronous flashing of beacons, dusk-to-dawn operation, lamp outage and failed flasher alarm modules, three-phase voltage monitors and more.

Circle (423) on Fast Fact Card

Guide features 10,000 products

Hutton Communications' *1997 Product Selection Guide* features 10,000 products from more than 100 wireless communications and power systems equipment manufacturers. Included are infrastructure products, test and shop equipment, radios and accessories, cellular and PCS accessories, and power systems equipment. The guide is divided into 10 sections with product descriptions, photos and charts.

Circle (424) on Fast Fact Card

Book provides information about intelligent transportation systems

Vehicle Location and Navigation Systems, written by Yilin Zhao and published by **Artech House,** includes information that helps you design and implement advanced intelligent transportation systems (ITS). This book covers the principles and practical applications of modern vehicle location and navigation systems, from digital map databases, to positioning sensors and fusion methods, to human-machine interface technologies. It also addresses newly developed technologies including a fuzzy logic-based algorithm, the field-emitter display (FED), and a recently invented software technology for 3D map display.

Circle (425) on Fast Fact Card

People

Schmidt

Oliphant

Campbell

Petty

John Schmidt leaves Progress Communications, Houston, as general manager to join Hutton Communications, Dallas, as director of business development for mobile and portable products.

Malcolm Oliphant departs Wavetek, Indianapolis, as systems engineer and joins IFR Systems, Wichita, KS, as director of training.

Changes at Riser-Bond Instruments, Lincoln, NE:
Walter R. Campbell II, vice president of sales and marketing, moves up to president.
Marshall B. Borchert, president, advances to chief executive officer.

Colin Petty leaves Cylink as vice president of international sales to join Pacific Crest, Santa Clara, CA, as manager of international sales.

John Vice departs Habitech, Seattle, to join BCS Wireless, New Glarus, WI, as vice president of construction.

Ken Krassy leaves Telecom, Bermuda, as general manager and joins Signal Communication Service, Miami, as vice president.

Stephen Greenspan, executive vice president of operations, Spectrian, Sunnyvale, CA, advances to executive vice president.

Steve Schneller, east coast regional sales manager, Andrew, Orland Park, IL, moves up to national sales manager.

Jess Rosenthal departs NEC Electronics, Somerset, NJ, as worldwide account manager for the AT&T/Lucent account to join Telecom Analysis Systems, Eatontown, NJ, as vice president of sales.

Jerry Miller leaves Pro-Guard Industries, Indianapolis, as president to join Gamber-Johnson, Stevens Point, WI, as general manager. He succeeds **Brad Johnson,** who retires.

Tom Crawford departs Qualcomm, San Diego, as director of strategic accounts to join Metawave Communications, Redmond, WA, as director of product marketing and business development.

Margaret Tutwiler, president of Direct Impact Communications, Alexandria, VA, joins CTIA, Washington, DC, as senior vice president for public affairs and communications.

Michael Guerin leaves Motorola, Schaumburg, IL, as product manager in the Wireless Networks Solutions Group and joins Comsat RSI Wireless Antennas, Des Plaines, IL, as vice president of marketing.

Letters from readers

Refarming:

It is necessry to correct for your readers an inaccurate statement that appeared in Robert H. Schwaninger's article titled "Refarming: The Telecom 'Agribusiness' of the Next Decade," published in the May 1997 issue.

Specifically, Mr. Schwaninger writes that "...the FCC is adopting the LMCC-ITA plan of dividing all of the spectrum below 470MHz into two pools, private wireless and public safety." Actually the two pools have been classified Industrial/Business and public safety. Further, as secretary/treasurer of the Land Mobile Communications Council (LMCC), I can assure you that the LMCC never presented any recommendation to the Federal Comunications Commission regarding the consolidation of the private land mobile radio services. The LMCC did, however, submit other proposals regarding system transition and related technical matters.

Finally, Mr. Schwaninger writes that "services like telephone maintenance..., motion picture and others appear to be fading... " Your readers may be interested to know that the spectrum management and frequency coordination functions associated with the Telephone Maintenance and Film and Video Production Radio Services have been conducted by ITA under formal agreement with the Telephone Maintenance Frequency Advisory Committee and the Alliance of Motion Picture and Television Producers, the FCC-certified frequency advisory committees, for these radio services for over 10 years. We suspect that the licensees within these services will continue to receive the level of service to which they have become accustomed, and they are, in fact, looking forward to the opportunities that "refarming" creates.

Mark E. Crosby
President
Industrial Telecommunications Association
Arlington, VA

Mr. Schwaninger's response:

In response to Mr. Crosby's letter, I wish to thank him for his greater insight into the participation of the parties who assisted the FCC in its efforts to come forward with their refarming initiative. His letter serves to better inform the readers, and that's what we all are trying to accomplish. Although I am not a proponent of refarming, I certainly understand the motivations of ITA and LMCC in their efforts to make rational the FCC's proposed rule changes and to lessen any adverse impact on their members and other operators throughout the industry.

As for the continued participation by frequency coordination groups, I was aware of ITA's long service to groups like the Telephone Maintenance Frequency Advisory Committee and the professionalism that ITA has provided in performing many of the frequency coordination functions of several of the coordinating entities. My comments were directed at whether the entire function would be taken up by ITA, and whether such groups would simply disband in favor of ITA's continued efforts. There is no doubt that each of these groups has been served well by ITA's efforts and will continue to enjoy ITA's deft handling of their concerns. Any suggestion to the contrary was unintentional.

Again, I wish to thank Mark Crosby. His letter only helps to illuminate further the issues surrounding refarming, to the benefit of all.

Robert H. Schwaninger Jr.
Partner
Brown & Schwaninger
Washington, DC

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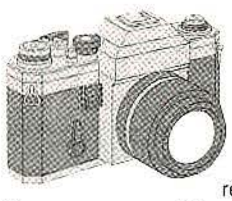

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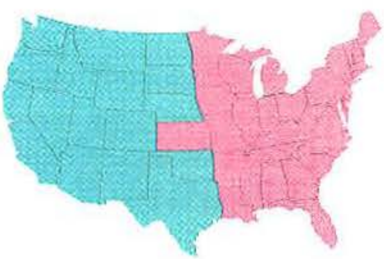

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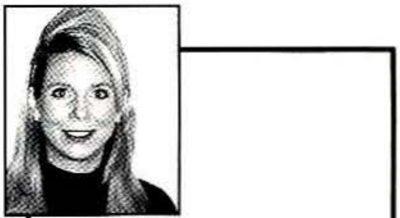

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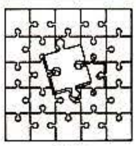

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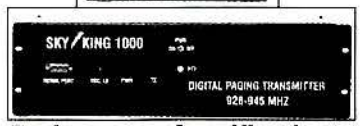

Performance Specifications

AC Power Voltage	90–130v
Frequency	47–63Hz
DC Power	13.8v DC, 5 amp Exciter 5v DC, 2 amp Exciter 28v DC, 10 amp PA
Frequency Generation	Synthesized 928–945MHz
Channel Spacing	12.5KHz
Spurious & Harmonic Emissions	–80dB
Frequency Deviation	5000Hz (max)
Frequency Stability	.05 ppm
FM HUM 7 noise	–40 dB
Pager Signaling	Digital, POCSAG/GOLAY
Baud Rates	0–1200 bps
Modulation type	FSK
FCC Emissions	16KOF1D, 15KOF2D
Power Output	Exciter: 120–400mW PA: 45 W min (selectable)
Antenna Impedance	50 ohms
Operating Temperature	-30 C to +60 C –22° F to +140° F
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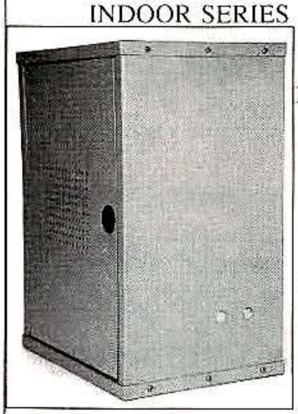

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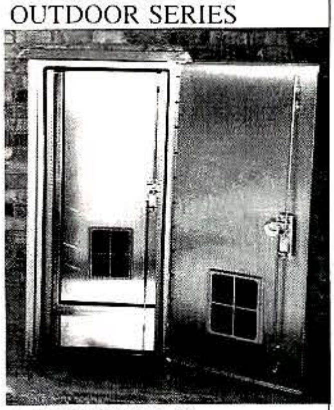

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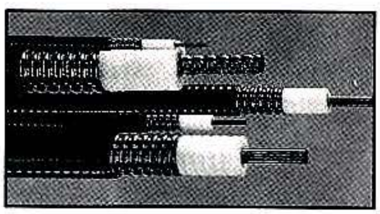

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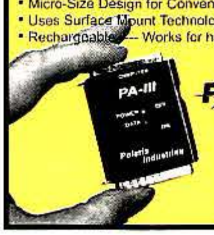

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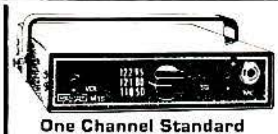

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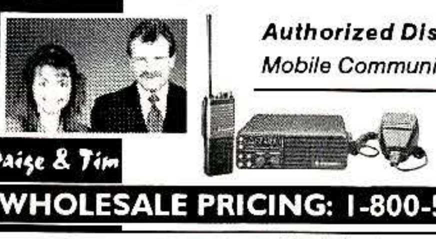

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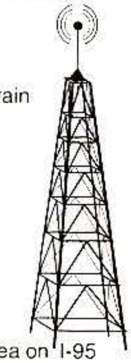

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Ad index/hot line

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Advanced Systems Corp.	49	65	800-233-0013
AEA A Div. of Tempo Research	16	9	760-598-8900
Allen Telecom Group	IFC	1	800-676-5342
Anchor Graphics Inc.	83	130	972-242-0439
Andrew Corp.	14	7	708-349-3300
Antenex	75	109	800-323-3757
AF Comm Supply	76	112	800-255-6222
ARS	40	46	817-595-4292
ARS	77	115	817-595-4292
Astron Corp.	7	17	714-458-7277
Avcom of Virginia	67	64	804-794-2500
Avtec Inc.	62	38	803-892-2181
Barnett Electronics	72	104	800-423-3858
Barnett Electronics	74	107	800-423-3858
Bee Electronics Inc.	26	25	800-336-3115
Berkeley Varitronics	12	20	908-548-3737
Bird Electronic Corp.	38	44	216-248-1200
Castle Tower Corp.	87	138	713-789-7651
Celwave	3	5	800-321-4700
ChargeGuard Corp.	76	113	800-458-3410
Communications Data Serv.	85	135	703-558-0510
Communications Mktg Grp Inc.	78	116	800-336-6825
Communications Specialists	BC	3	800-854-0547
Computer Resources Inc.	84	134	205-987-1523
Connect Systems Inc.	13	6	800-545-1349
Control Signal Corp.	44	49	303-989-8000
CPI Communications Inc.	51	36	972-437-5320
Cruising Equipment	49	39	206-782-8100
Crystronics Inc.	72	102	954-776-0031
CTI Products Inc.	66	41	513-595-5900
CTI Products Inc.	81	123	513-595-5900
CueMeks Electronics	76	110	915-533-4453
DDB Unlimited	74	106	800-753-8459
Destel USA Inc.	75	108	817-738-8390
Direct Power & Water Corp.	44	50	505-889-3585
D & L Communications Inc.	78	116	800-336-6825
Doppler Systems Inc.	60	62	602-488-9755
Duracomm Corp.	56	54-55	816-472-5544
EAGLE	56	40	520-204-2597
El Paso Comm. Systems	80	121	915-533-5119
Gencron Engineering Inc.	84	131	619-792-1141
General Communications	83	129	800-356-3200
Henry Radio	64	57	800-877-7979
Hewlett Packard	33	28	509-921-4001
Hustler Inc.	31	15	800-949-9490
Hutton Communications	9	18	800-442-3811
ICT	37	72	604-888-6304
IFR Systems Inc.	11	19	316-522-4981
Kaval Electronics Inc.	29	13	905-940-1400
Kenwood Communications	15	8	800-950-5005
King Communications USA Inc.	62	67	407-291-9009
Klein Electronics	76		619-631-2811
Leavitt Communications Inc.	28	27	847-676-8282
Lindgren RF Enclosures Inc.	65	71	708-307-7200
Marquis Microwave Products	20	12	847-519-2177
Maxrad Inc.	25	24	630-372-6800

Company	Page Number	Fast Fact Number	Advertiser Hotline
McManus Communications	80	122	501-763-6250
Mechem Electronics	76	111	540-891-0569
Micropath Corp.	85		303-526-5454
Midian Electronics Inc.	41	47	520-884-7981
Modular Comm. Systems	18	10	818-764-1333
Motorola Paging	73	105	561-739-8703
Motorola Test Equipment	5	16	800-505-TEST
Norcomm Corp.	66	42	916-477-8400
NSI	81	125	253-946-2426
Optaphone Systems	60	61	707-923-4000
Optoelectronics Inc.	21	21	800-327-5912
Otto	30	14	708-428-7171
PageCo International Inc.	72	102	954-776-0031
PageCorp Industries	72	103	800-957-8700
P.C.I.A.	47		703-739-0300
Pipo Communications	83	128	916-644-5444
Polaris Industries	79	120	404-872-0722
Polyphaser Corp.	35	30	800-325-7170
Portable Radio Service	85	137	573-472-1889
Procomm	77	114	805-497-2397
Pyramid Communications	82	126	310-430-5892
Radio Express Inc.	84	132	703-266-1928
RCC Consultants	69	100	902-636-6970
RCW Distributing	78	117	800-726-9015
RF Design '97	45	31	800-288-8606
Ritron Inc.	54	52	800-USA-1USA
Ritron Inc.	61	37	800-USA-1USA
RoameR One Inc.	22	22	800-306-ROAM
Selectone	48	33	510-781-5432
Sentry Manufacturing Co.	72	101	800-252-6780
ServiceWare Corp.	58	59	819-770-4000
Sharp Communication	82	133	800-548-2484
Site Advantage	53	51	516-367-6732
Smartrunk	27	26	510-887-1950
SoftWright	85	136	303-344-5486
Survey Technologies	46	32	503-591-5986
Sutter Buttes Two-Way	81	124	916-674-7532
Telewave Inc.	43	48	415-968-4400
Tessco	17		800-472-7373
Thunder Eagle	67	63	703-242-0122
Times Microwave Systems	19	11	203-949-8400
TPL Communications Inc.	59	58	213-256-3000
Trident Micro Systems	34	29	800-798-7881
Tripp Lite	55	53	312-755-8741
Trylon Mfg. Co., Ltd.	58, 63	60,70	519-669-5421
U Trunk Repeaters	82	127	619-469-3077
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Vocom Products Co. LLC	50	35	800-USA-MADE
Wacom Products Inc.	63	66	817-848-4435
Wetec	79	119	800-264-1175
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